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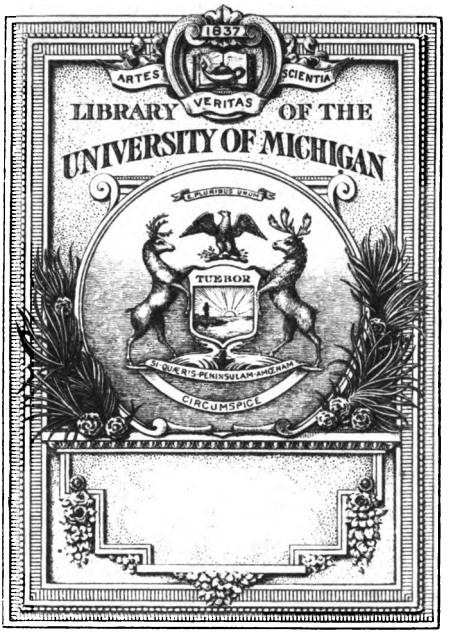

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REPORT

OF THE

BOARD OF VISITORS

TO THE

UNITED STATES NAVAL OBSERVATORY.

1899.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1899.

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LETTER OF TRANSMITTAL.

WASHINGTON, D. C., *October 2, 1899.*

SIR: In compliance with the request contained in your letter of June 30, 1899, the undersigned have acted as a board of visitors to the United States Naval Observatory in Washington, and now submit their report, including subdivisions as follows:

I. Recommendations of the board of visitors.
II. Circumstances leading to the appointment of the board of visitors.
III. Cost of Observatory.
IV. Comparison with other observatories.
V. Present condition and methods of Observatory work and the delay in printing its results.
VI. Historical sketch of the Observatory.
VII. Minutes of the proceedings of the board of visitors.
VIII. Appendix.

The several portions of the report were put in form by the astronomers, who are members of the board. The recommendations are made unanimously.

Very respectfully,

WM. E. CHANDLER,
A. G. DAYTON,
EDWARD C. PICKERING,
GEO. C. COMSTOCK,
GEORGE E. HALE.

Hon. JOHN D. LONG,
Secretary of the Navy.

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REPORT OF THE BOARD OF VISITORS TO THE UNITED STATES NAVAL OBSERVATORY.

RECOMMENDATIONS OF THE BOARD OF VISITORS.

In accordance with the instructions contained in the following letter, all the members of the board of visitors to the United States Naval Observatory therein named met at the Observatory in Washington on Friday, June 30, 1899, and organized by the selection of William E. Chandler as chairman and George C. Comstock as secretary.

NAVY DEPARTMENT,
Washington, June 30, 1899.

GENTLEMEN: In accordance with previous correspondence and oral conversations, you are hereby requested to act as a board of visitors at the United States Naval Observatory in Washington, convening there to-day, and to proceed to examine into the condition of that institution and to report to me your conclusions and recommendations.

Very respectfully,

JOHN D. LONG, *Secretary.*

Hon. WILLIAM E. CHANDLER,
Hon. ALSTON G. DAYTON,
Prof. EDWARD C. PICKERING,
Prof. GEORGE C. COMSTOCK, and
Prof. GEORGE E. HALE.

Capt. Charles H. Davis, U. S. N., Superintendent of the Naval Observatory, presented to the board an informal statement of circumstances leading to the appointment of the board of visitors, and submitted correspondence relating thereto (Appendix, Exhibit A) and to a proposed reorganization of the Observatory (Appendix, Exhibit B). He also placed before the board a list of professors of mathematics upon the active list of the Navy (Appendix, Exhibit C), from which corps the staff of the Observatory is largely drawn, and a list of all persons performing duty at the Observatory, with their respective ranks (Appendix, Exhibit D).

At the request of Messrs. Chandler and Dayton, there was submitted to the board by its other members the correspondence conducted by them as a committee of the second annual conference of astronomers and astrophysicists for the purpose of obtaining the views of American astronomers and physicists upon the organization and work of the Naval Observatory. Mr. Pickering submitted to the board a statement regarding correspondence on the same subject conducted by a committee of the American Association for the Advancement of Science.

In view of the facts brought before the board at its several sessions, and after the best consideration which it has been able to give to the subject, the board of visitors reports and recommends as follows: The Naval Observatory, which was originally established as a scientific bureau, auxiliary to the needs of the naval service, has become, through half a century of growth and through the expenditure of large sums of money, as authorized by law, an astronomical observatory of the first rank in

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respect of buildings, instruments, and equipment. But by far the larger and more valuable part of its equipment has little or no reference to any direct requirement of the naval service, and its existence can be justified only on the ground that Congress has intended to establish and maintain a national astronomical observatory. Under these changed circumstances its continued connection with the Navy Department has seemed to many of those whose views have been submitted to the board of visitors illogical and undesirable. In view, however, of the absence of a national university, a department of science and industries, or other department or bureau of the Government especially suited to the conduct of such scientific work, and in view of the diversity of opinion among American astronomers upon the question to which existing Department the Observatory could be wisely transferred, we believe it to be inexpedient for us at the present time to further consider the subject of such transfer.

With reference to the organization of the Observatory under naval administration, the board of visitors disapproves of those parts of the "Proposed organization of the Naval Observatory" (Appendix, Exhibit B), submitted under date September 7, 1897, by "F. E. Chadwick, Chief of Bureau of Equipment, and C. H. Davis, Superintendent United States Naval Observatory," which require the establishment of a formal observatory council, with nominal functions, and which by omission practically abolish the office of astronomical director. We are by no means objecting to the assembling in conference of the astronomers engaged in observatory work, but the proposed transfer of duties and responsibilities from a single director to a committee of five appears to us a step in the wrong direction; and when, as under the proposed scheme, an absolute power of veto upon all action by the council is lodged in the hands of one of its members, the usefulness of the body seems to approach the vanishing point. In the history of observatories we have been unable to find a case of successful administration without a competent astronomer in immediate supervision of the work, and we believe that the ideal conditions for the successful administration of an astronomical observatory are most nearly realized when a professional astronomer is made the responsible director of the work. This system, which is adopted in every great national observatory, the board of visitors believes to be the one best suited to secure the astronomical efficiency of the Naval Observatory.

If the Naval Observatory as a shore station, charged with the performance of certain functions assumed to have a relation to the Navy, is to continue under the command of a line officer, we recommend that the astronomical staff of the Naval Observatory shall consist of an astronomical director, four astronomers, three assistant astronomers, and such computers and other minor officers as may be provided by law. The astronomical directors and astronomers, whether professors of mathematics or taken from civil life, and the assistant astronomers, should be appointed by the President, by and with the advice and consent of the Senate, to hold their offices until their successors are appointed.

The Nautical Almanac Office, which was formerly a distinct bureau, is now administered by departmental regulations as a part of the Naval Observatory, and it appears from the evidence submitted to the board of visitors that the successful administration of the observatory is much impeded by reason of imposing upon its astronomical director the duties of director of the Nautical Almanac. Each of these offices furnishes abundant employment for the entire time of an able astrono-

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mer, and we therefore recommend that there shall be a director of the Nautical Almanac appointed by the President, by and with the advice and consent of the Senate, to hold office until his successor is appointed.

We also recommend that provision be made for the continuation of the admirable series of memoirs published under the title "Professional Papers of the American Ephemeris and Nautical Almanac."

A criticism frequently and forcibly urged against the administration of the Naval Observatory, not limited to the present time but covering almost the entire period of its existence, is that its astronomical work has not been prosecuted with that vigor and continuity of purpose which should be shown in a national observatory. The possibility of conducting well-planned researches with unvarying regularity over long series of years should constitute the great advantage of a national observatory, an advantage which is not fully realized in the history of the Naval Observatory, where each principal astronomer seems to have been left to choose his own line of work and to alter it from time to time or abandon it. This is perhaps inevitable in a system which places at the head of an observatory an officer who is not a technical expert in astronomical work; and therefore in order to secure continuity in the prosecution of work well chosen and coordinated with that of other observatories, and also to obtain for the observatory and the Department advice and criticism which shall be both disinterested and responsible, we recommend the establishment of a permanent board of visitors, substantially as follows:

There shall be appointed by the President from persons not officers of the United States, a board of nine visitors to the Naval Observatory, six to be astronomers of high professional standing and three to be eminent citizens of the United States. Appointments to this board shall be made for periods of three years, but provision shall be made by initial appointments for shorter terms so that two astronomers and one member of the board not an astronomer shall retire in each year. Members of this board shall serve without compensation, but the Secretary of the Navy shall pay the actual expenses necessarily incurred by members of the board in the discharge of such duties as are assigned them by the Secretary of the Navy or are otherwise imposed upon them. The board of visitors shall make an annual visitation to the Naval Observatory at a date to be determined by the Secretary of the Navy, and may make such other visitations not exceeding two in number annually by the full board, or by a duly appointed committee as may be deemed needful or expedient by a majority of the board.

The board of visitors shall report to the Secretary of the Navy at least once in each year the result of its examinations of the Naval Observatory as respects the condition of buildings, instruments and apparatus, and the efficiency with which its scientific work is prosecuted. The board of visitors shall prepare and submit to the Secretary of the Navy regulations prescribing the scope of the astronomical and other researches of the Naval Observatory and the duties of its staff with reference thereto. When appointments or details are to be made to the office of astronomical director, director of the nautical almanac, astronomer, or assistant astronomer in the Naval Observatory, the board of visitors may recommend to the Secretary of the Navy suitable persons to fill such offices, but such recommendations shall be determined only by a majority vote of the members present at a regularly called meeting of the board held in the city of Washington.

Special attention is at this point called to the fact that the appoint-

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ment of a board of visitors to the Naval Observatory was recommended by Secretary Tracy in 1891, has been repeatedly urged by superintendents of the Observatory, and is renewed by F. E. Chadwick, Chief of Bureau of Equipment, and C. H. Davis, Superintendent United States Naval Observatory, in the "Proposed organization of Naval Observatory," dated September 7, 1897 (Appendix, Exhibit B). The duties of the board, as defined by these naval officers, would be in part as follows: "It lays down the general course of policy to be pursued for the coming year, including printing and publication of observations; fixes the estimates for the astronomical departments; nominates to fill vacancies in the astronomical staff (either by appointment or promotion); recommends as to repairs and acquisitions of new instruments."

If a permanent board of visitors as above recommended is established as a part of the administration of the Naval Observatory, it is evident that to it should be committed those questions of policy to be pursued in the conduct of the Observatory which are contained in the memorandum (Appendix, Exhibit B) submitted to the present board by the Secretary of the Navy under date of June 28, 1899. We therefore abstain from specific recommendations upon these subjects, many of which indeed call for a more prolonged and minute study of the situation than the members of the present board have been able to give to it.

We heartily indorse the recommendation contained in your report as Secretary of the Navy for the year 1897, that "the statute authorizing the appointment of professors of mathematics be so amended that without disturbing those who now hold office, which would be unjust to them, no further appointments shall be made" to the staff of the Naval Observatory (Appendix, Exhibit L). In addition to the reasons for this action which are urged by you in that report, we submit for your consideration that the conditions under which astronomical work is done are so different from those which obtain in the naval service that a fixed tenure of office, with the certainty of a retiring pension in no way dependent upon the zeal or efficiency with which service has been rendered, may easily produce diminished diligence and a purely perfunctory discharge of duties. A more serious evil of the existing system of naval commissions for astronomers, which has been forcibly exemplified within the past decade, is the compulsory retirement at the age of 62 of astronomers who are then in the maturity of their powers and who under civilian appointments would continue to render to the Observatory a service of undiminished efficiency which they now transfer to other institutions. The reasons which impel the retirement of a naval officer from active service upon attaining a fixed age have no application in the case of an astronomer, and he should be placed upon the same footing with other officers of the Government performing strictly civilian duties.

If astronomers are appointed to the Naval Observatory from civil life to succeed retiring professors of mathematics the salaries provided should be sufficient, as recommended by you in that report for 1897, "to make up for the refusal to them of the privilege of retirement and also to secure men of high scientific attainments adequate to the demands of one of the most capable observatories in the world." To secure the services of the ablest astronomers the salaries provided should be slightly larger than those paid in the higher class of university observatories, and account should be taken of the fact that university vacations are much longer than leaves of absence from the public service. The board of visitors recommends the following as a

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schedule of salaries which could be expected to attract astronomers of the class desired:

Astronomical director	$6,000
Director of Nautical Almanac	5,000
First astronomer	4,000
Second astronomer	3,600
Third astronomer	3,200
Fourth astronomer	2,800
First assistant astronomer	2,400
Second assistant astronomer	2,200
Third assistant astronomer	2,000

The experience of every great observatory shows that the efficiency of its staff is materially increased by the provision of quarters near the observing rooms for those persons who are engaged in work by night, and we recommend that there should be quarters provided upon the Observatory grounds for all members of the astronomical staff regularly assigned to night work.

In concluding its recommendations the board of visitors wishes earnestly to urge upon your consideration the necessity of making a success of the movement which you have begun in order to improve the condition of the Naval Observatory and to make its administration satisfactory to the great body of the astronomers of the country and to the public.

Some of our recommendations, if they meet your approval, can be carried into effect by departmental action, but the changes which we regard as vital can only be obtained through legislation by Congress. If such legislation is withheld the continuance of present conditions is sure to result in a renewed, persistent, and possibly acrimonious demand for the removal of the Observatory from naval control. If, however, the legislation is enacted and the improved system is given a fair trial, unquestionably much improvement will result, and it is not improbable that the Observatory will attain and hold that high standing in the scientific world which should be required of such an institution.

To help bring about such a desirable consummation we have complied with your request, although not made in pursuance of any law, that we should visit and investigate the Observatory, and we have recommended specific measures which we hope will lead to those reforms in administration which are imperatively necessary if the Observatory is to receive and retain the confidence and support of the astronomers and scientists of the world.

CIRCUMSTANCES LEADING TO THE APPOINTMENT OF THE BOARD OF VISITORS.

At the dedication of the Yerkes Observatory in October, 1897, a conference of astronomers and astrophysicists was held, in which fifty-seven members took part. The results of this meeting were so satisfactory that a second conference was held at the Harvard College Observatory in August, 1898. Ninety-two members were present, and the astronomers of this country were well represented at these two conferences, which have resulted in the formation of a permanent astronomical society. At the second conference one morning was devoted to the discussion of the condition of the Naval Observatory. The opinion was nearly unanimous that the scientific output did not represent the equivalent of the appropriations made. Numerous remedies were proposed and a committee was appointed with instructions to collect the opinions of American astronomers and to bring the subject before the

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Secretary of the Navy. To secure the individual choice of the members, this committee was elected by ballot without previous nomination of candidates, and resulted in the selection of Edward C. Pickering, director of the Harvard Observatory (chairman); George E. Hale, director of the Yerkes Observatory of the University of Chicago (secretary), and George C. Comstock, director of the Washburn Observatory of the University of Wisconsin.

During the following week the American Association for the Advancement of Science met in Boston. Nearly a thousand members were present, representing all departments of science. At a meeting of its council held August 25, 1898, a committee consisting of Edward C. Pickering, chairman; T. C. Mendenhall, president of the Worcester Polytechnic Institute, and R. S. Woodward, professor of mechanics in Columbia University, were appointed to cooperate with the committee of the Astrophysical Conference. The latter committee at once prepared the circular given in the Appendix (Exhibit E), and sent copies to the leading astronomers of the country, whose names are given in the Appendix (Exhibit F). A complete summary of the replies is given in the Appendix (Exhibit G), the originals remaining with the secretary of the Astronomical and Astrophysical Society of America. Sixty-one replies were received. Counting opinions materially qualified by expressions of doubt as only one-half, it appears that the opinion was nearly unanimous that a change in organization is desirable (51 to 2), that the entire direction should be intrusted to an astronomer (54 to 3), that advancement should depend on efficiency rather than upon seniority (50 to 2), and that a visiting committee should be appointed (43 to 6). On the other hand, opinion was nearly equally divided as to whether the Observatory should be transferred to another Department of the Government (19 to 19), or whether certain branches should be separated from it (26 to 24). It was emphasized in these replies that if an astronomer was made director he must be a man of marked executive ability, and that a visiting committee would be of little use if it had no power to enforce its recommendations. The majority of the committee of the American Association expressed the decided opinion that no change was likely to result in any decided improvement unless the Naval Observatory should be transferred from the Navy to some other Department of the Government. In this connection see Science IX, pages 469, 470.

Meanwhile, the editor of Science, recognizing the widespread interest in the matter among the astronomers of the country, published three elaborate articles on the Naval Observatory (Science IX, pp. 1–65, 859). The second of these was accompanied by the replies to a circular containing the following questions:

1. Is it desirable that the Government of the United States should support a national astronomical observatory?
2. If so, what ends should such an institution have in view; especially to what classes of astronomical observation and research should it be devoted?
3. Does the new Naval Observatory fulfill the objects in question so completely that no other institution of the kind is necessary? If not, in what respects does its work differ from that required for the purposes in view?

A meeting of the committee of the Astrophysical Conference was held at Washington in February, 1899, and a memorandum of their report was presented to the Secretary of the Navy, in substance as follows:

REPORT OF COMMITTEE OF ASTROPHYSICAL CONFERENCE.

At the Harvard Astronomical Conference held in Cambridge on August 18, 1898, the undersigned were appointed a committee to consider what changes, if any, were

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advisable in the organization of the United States Naval Observatory. A circular was sent to the principal astronomers in the United States asking six questions regarding means of increasing its astronomical efficiency. Sixty-one replies were received, with the following approximate results, doubtful answers being counted as one-half.

1. A change in organization is recommended: 51 to 2.
2. The entire direction of the Observatory should be intrusted to an astronomer. 54 to 3.
3. Transfer of the Observatory to some other Department of the Government: 19 to 19.
4. Separation from the Observatory of various branches, such as the testing of nautical instruments: 26 to 24.
5. Tenure of office and advancement should depend on scientific efficiency rather than upon age or length of service: 50 to 2.
6. A visiting committee should be appointed: 43 to 6.

It therefore appears that opinion is nearly equally divided whether a portion or the whole of the Observatory should be transferred to some other Department, but is nearly unanimously in favor of changing the present organization, of intrusting the entire direction to an astronomer, of making advancement depend on scientific efficiency, and of appointing a visiting committee. To be efficient this committee should have power to act and should consist of experts who would serve without pay.

In March, 1899, the Secretary of the Navy decided to create the present board of visitors to the Naval Observatory.

COST OF OBSERVATORY.

The financial condition of the Observatory is shown in the Appendix, Exhibit H, which gives the total cost of grounds and buildings to July 1, 1899, to be $473,200; estimated value of the grounds, buildings, and instruments, $856,547.35; annual appropriations for the year ending June 30, 1899, $51,160, and annual appropriations for grounds and roads for the same year, $11,200. To the current expenses of $51,000 should be added several items really paid for by the Government but not included in the above appropriations. Their amounts will vary from year to year, and can only be estimated approximately. They include: First, the salaries of the Superintendent and other line officers detailed for duty at the Observatory; estimated amount, $6,000. Second, salaries of professors of mathematics. There are now five of these at the Observatory, besides one temporarily ordered to the Bureau of Yards and Docks; estimated amount, $15,000. Third, retired pay of professors of mathematics who served as astronomers; estimated amount, $10,000. Fourth, cost of printing publications; estimated amount, $3,000. According to these estimates, the total annual cost to the Government exceeds $85,000, not including expenditures for the Nautical Almanac. In any plan for reorganization the sum of $85,000 annually should therefore be assumed as that available, unless it is the intention of Congress to reduce the expenses rather than to increase the amount of useful work accomplished.

COMPARISON WITH OTHER OBSERVATORIES.

From a comparison of the resources of the Naval Observatory with those of the principal observatories of the world, it appears that the observatories having the largest annual incomes are as follows: Naval Observatory, $85,000; Paris, $53,000; Greenwich, $49,000; Harvard, $46,000; Pulkowa, $46,000; Cape of Good Hope, $33,000. The resources of some of the richest private observatories are not published, but it is probable that none of them would exceed those of the Cape Observatory. The incomes of the greater portion of the observatories of the world, both public and private, are far less than those mentioned above.

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The work of the Greenwich Observatory may fairly be compared with that of the Naval Observatory, since both institutions are supposed to cover nearly the same field. It might well be asked whether the Naval Observatory, with much greater resources than the Greenwich Observatory, furnishes contributions to astronomy of equal value.

The conditions for scientific work in Europe are, however, so different from those in America that it is more instructive to compare the details of organization with those of an American observatory. The Harvard Observatory is selected for three reasons. First, both institutions undertake large pieces of routine work which are beyond the reach of the smaller observatories. In this respect they differ from the other American observatories, whose officers are mainly specialists engaged in individual research. Secondly, the resources of the Harvard Observatory approach more nearly than do any other those of the Naval Observatory. Thirdly, all details of the Harvard work are readily available.

Grounds.—The Naval Observatory grounds cover 70 acres, valued, with the improvement made of the grounds, at $66,000. The Harvard Observatory grounds cover 7 acres, having an estimated value of $50,000. These last grounds are too small and too near thickly settled portions of the city. The climates of Washington and Cambridge are not suitable for astronomical observations of the highest grade. Harvard has established a secondary station in Arequipa, Peru, at a height of 8,000 feet, selected after careful study as the location in which the atmospheric conditions are more favorable than had been found in any other part of the world. Six meteorological stations, extending from the sea level to a height of 19,200 feet, are associated with it. The observatory is also closely related with the Blue Hill Meteorological Observatory, which is not included in the present discussion.

Buildings.—The buildings of the Naval Observatory are valued at $457,512.83, those at Cambridge at $52,000, and those at Arequipa at $12,000. The Harvard buildings are very inadequate, and for the most part are not fireproof.

Instruments.—The principal instruments at the Naval Observatory are the 26-inch equatorial telescope, the 12-inch equatorial telescope, the 9-inch transit circle, the 6-inch transit circle, the 5-inch altazimuth, and the prime vertical transit instrument. In general the work done with these instruments does not differ from that done elsewhere. The 9-inch transit circle is not now in use, but in the past it has done useful work, including the observation of one of the international zones.

The principal Harvard instruments at Cambridge are the 15-inch equatorial telescope, the 15-inch reflector, the 12-inch meridian photometer, the 11-inch Draper telescope, the 8-inch transit circle, the 8-inch Draper doublet, the 6-inch equatorial telescope, and the 4-inch transit photometer. The principal instruments at Arequipa are the 24-inch Bruce doublet, the 13-inch Boyden, visual and photographic, equatorial telescope, the 8-inch Bache doublet, the 4-inch meridian photometer, and the 4-inch transit photometer. The 8-inch transit circle is not now in regular use, but with it two of the international zones have been observed. All of the other instruments are in regular use every clear night, nearly all of them until dawn, and the work done with them is not duplicated elsewhere.

Permanence of direction.—Each piece of work undertaken at a large observatory should extend over several years and in some cases indefinitely. Changes greatly diminish the value, and should be made only when absolutely necessary. Continuity of work is best secured by long

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tenure of office of the executive officer. At the Naval Observatory ten superintendents have held office during the last thirty-three years, not including those serving ad interim, the average term being three years and one-third. Some of these served two or three times, with intervals filled by other officers. (See Appendix, Exhibit I.) The rules of the service render difficult the long continuance of an efficient officer on shore duty. The Greenwich Observatory, established in 1675, has had eight directors in two hundred and twenty-four years, the average term being twenty-eight years. The Harvard Observatory, established in 1840, has had four directors in fifty-nine years, the average term being fifteen years. Of these two institutions nine of the directors have died in office, one retired at the age of 80 years, and none of them have ever resigned to accept positions elsewhere.

Salaries.—The principal item in the expenses of an active observatory is the salaries of its officers. For the Naval Observatory this item amounts to five-sixths of the entire expenditure. It is therefore of importance to compare the scale of salaries and the proportion of high and low grade officers.

The approximate number of persons of various grades and their average salaries at the Naval and Harvard observatories are given below:

Officers.	Naval Observatory.		Harvard Observatory.	
	No.	Salary.	No.	Salary.
Directors	2	$4,000	1	$5,000
Astronomers	4	3,000	6	2,000
Assistant astronomers	3	1,900	13	900
Computers	8	1,200	18	600
Skilled artisans	6	1,200	1	700
Laborers	20	700	3	600
Total	43	.....	42	.....

It should be stated, however, that some of the assistants at Harvard devote only a portion of their time to this work and receive proportional salaries, the effect not being sufficient to materially alter the conclusions.

The dual head of the Naval Observatory is, of course, the most striking feature in this comparison. This alone gives an undue cost to the management of the Naval Observatory. The salary of the astronomical director is small, considering the importance of the position. As he is a professor of mathematics, his salary may be $2,400, $2,800, $3,200, or $3,500. The Superintendent, in addition to his salary, has the use of a suitable house. A house is provided for the director at the Harvard Observatory, but the rent is deducted from his salary. It has not been customary for the Superintendent of the Naval Observatory to take part in the scientific work of the institution, and the astronomical director does not make observations. The Harvard directors, in addition to their work in the daytime, have always taken part in the observations, the work for the last twenty years averaging over four hours on every clear evening.

In nearly all military and civil establishments the officers of low grade are much more numerous than those of high grade. There are many more captains than admirals. At the Naval Observatory this difference is much less than at Harvard. At both institutions the observations consist mainly of large pieces of routine work. These are planned by

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the directors and astronomers, who may also make the observations, but the great labor of computation and reduction is done by the assistant astronomers and computers. The latter can do as much of this work, which is often mere copying, as officers receiving much higher salaries, and it will be noticed that their number at Harvard (31) is nearly three times that at Washington (11). The naval appropriations provide for an instrument maker, an electrician, a photographer, a carpenter, an engineer, and a skilled laborer. At Harvard there is one instrument maker, who, however, has a machine shop. No adequate shop is provided at Washington. The photographic and similar work at Cambridge is done mainly by the assistant astronomers and computers. Ten of the laborers at Washington take care of the grounds, which are ten times as extensive as those at Cambridge. The large number of watchmen (6 and a captain of the watch) is perhaps justified by the value of the property to be guarded. The great difference in salaries at Washington and Cambridge, especially for the officers of lower grade, is probably unavoidable. This is partly due to civil-service rules, which, as sometimes administered, also render it difficult to discharge a man who proves to be unfit for his position. The alternative of political appointments would, however, be fatal to the scientific usefulness of the institution.

It is evident that the liberal appropriations made to the Naval Observatory should render it the greatest observatory in the world. The principal hindrances as compared with other observatories seem to be—(1) The relation of the Observatory to the Government, which makes its management complex; (2) frequent changes in its executive officer, which render a policy of long continuance difficult; (3) the salaries must be much higher than in private institutions to secure equally good men; (4) promotions in cases of special skill and removal in cases of inefficiency are difficult; (5) specific expenditures must be provided for in advance and can not be changed if conditions alter. Many of these difficulties would be diminished with an efficient and active executive, thoroughly familiar with the scientific work of the institution and having power to enforce needed reforms. A board of visitors, independent of Government control, but having power to make necessary changes, would greatly aid such an executive.

PRESENT CONDITION AND METHODS OF OBSERVATORY WORK AND THE DELAY IN PRINTING ITS RESULTS.

CONDITION AND METHODS.

Owing to the lack of printed material representing the recent work of the Naval Observatory, the board of visitors finds it practically impossible to form a satisfactory opinion upon the character and condition of that work without devoting to the task an inadmissible amount of time and labor. The last volume of published results is the one for the year 1890, and the results of subsequent work, so far as they are available at all, are only to be found in scattered communications to scientific periodicals. This backward state of the printing is greatly deplored by the superintendent and astronomical director, who represent it to be the result of temporary causes not likely to recur in the future, and estimate that the arrears of printing can be brought up within a period of four years. However this may be, the board of visitors at the present time can only express general opinions with respect to the condition of the work of the Naval Observatory. It appears indisputable, as already shown, that the expenditure of a given

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sum of money upon astronomical work at the Naval Observatory does not furnish results at all comparable with those obtained by a similar expenditure in other American observatories. This excessive cost may be in part due to the high scale of salaries paid to minor officers in the Government service, but in part at least it appears to be due to the defective organization of the work of the Observatory. For example, a single meridian instrument absorbs by far the larger part of the astronomical staff of the Observatory, and it appears to be the practice to assign a given observer to this instrument for only one day in each week and to excuse him from observing work at all other times. Since on the average one half of the nights are cloudy, this system gives to each observer but little more than two days per month for observations and uses the rest of his time given to the public service in clerical work. This appears to the board of visitors to be the reverse of economical in its expenditure of the energies of the staff.

It also appears from the statements submitted to the board by members of the staff of the Naval Observatory that in some instances at least there have been great delay and procrastination in the execution of work undertaken. This seems to be especially true in the case of the large equatorial telescope, which has yielded few results of importance since its removal to the new Observatory. The exact responsibility for this condition of things does not clearly appear.

PUBLICATION.

Two methods may be employed in publishing the results of the work of an observatory: First, printing in detail the original observations, with comparatively little discussion of them; second, publishing the conclusions derived from the observations. The first method is that adopted at Greenwich and followed at Washington. Its advantages are that all the material accumulated at the institution is placed promptly in the hands of astronomers, and that the great cost of the reduction and the consequent delay are saved. To render observations of much use, however, the reduction must then be undertaken elsewhere. The second method is followed at Pulkowa and at many other institutions. The extent of the publication in this case is no test of the value of the work and almost indefinite delays may occur before it is reduced and published. Thus the observations made at Pulkowa in 1842 were not published until 1869.

It may be a question whether the publication of the Washington observations should continue to follow the first method; but if not, a radical change should be made only after careful consideration. A combination of both methods, which is used at many observatories, is perhaps preferable. But if the first method is to continue there seems to be no reason why the publications of each year should not appear promptly and regularly. If the system is unchanged for many years, the extent of the publication will give at least an approximate idea of the amount of material collected. The last volume published at Washington contains the results for 1890; at Greenwich, those for 1896. The accompanying memorandum (Appendix, Exhibit J) shows the progress made in the preparation of the Washington observations for publication. If the plan proposed could be carried out it would be entirely satisfactory, but since no volumes have been published during the last four years it seems doubtful if twelve volumes can be printed in the next four years.

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HISTORICAL SKETCH OF THE OBSERVATORY.[1]

In 1832, when reporting to the British Association for the Advancement of Science on the progress that had been achieved in practical astronomy up to that time, Professor Airy remarked on his inability to speak of American astronomy, because he knew of the existence of no public observatory in the United States. Prior to this date little or nothing had in fact been done of a nature to attract the attention of a European astronomer. Professor Winthrop, of Harvard, had indeed recorded observations of eclipses and various other phenomena, made toward the middle of the eighteenth century, and the transit of Venus of 1769 had been ably observed under the direction of a committee of the American Philosophical Society. Rittenhouse, one of the observers on this occasion, had invented the collimating telescope, afterwards independently invented by Bessel. Bowditch had completed his great translation of the Mécanique Céleste, and Bond had made many observations with his small instrument near Boston and in Cambridge. But no public observatory had been established, and not even a beginning had been made in founding any of the great institutions which have since become so well known.

On March 28, 1810, Mr. Pitkin, of Connecticut, reported in the House of Representatives on the necessity of "laying a foundation for the establishment of a first meridian for the United States by which a further dependence on Great Britain or any other foreign nation for such meridian may be entirely removed." The appointment of a select committee, of which Mr. Pitkin was chairman, resulted from the presentation of a memorial by Mr. William Lambert, who had deduced the approximate longitude of the Capitol from observations of an occultation of Alcyone, made near the President's house on the night of October 20, 1804. On July 3, 1812, Secretary of State Monroe, to whom the memorial had been referred, stated through the Speaker of the House that "the Secretary of State has no hesitation to declare his accord with the committee in their opinion in favor of the establishment of a first meridian for the United States, and that it should be at the city of Washington, the seat of their Government. * * * It is known that the best mode yet discovered for establishing the meridian of a place is by observations of the heavenly bodies, and that to produce the greatest accuracy in the result, such observations should be often repeated, at suitable opportunities, through a series of years by means of the best instruments. For this purpose an observatory would be of essential utility."

The committee to which Mr. Monroe's reply was referred reported "that, in their opinion, astronomical observatories are highly useful to a navigating and commercial people * * * and that the most ready way of obtaining the information they desired, from noting the phenomena of the heavens, is by the establishment of an observatory. This may be erected at the city of Washington. By such an institution, means may be adopted, not only to fix the first meridian, but to ascertain a great number of other astronomical facts and occurrences through the vigilance of a complete astronomer."

[1] The preparation of this historical sketch was intrusted by the board of visitors to one of its members, who assumes responsibility for the statements it contains. Professor Nourse's "Memoir of the Founding and Progress of the United States Naval Observatory" has furnished much valuable material, particularly for the introductory pages. References to various other authorities which have been consulted are given in the appended bibliography (Appendix, Exhibit M).

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For various causes no action was taken upon the bill accompanying this report. In 1815 the original documents of Mr. Lambert and the Secretary of State were referred to a committee which reported in favor of erecting a national observatory. The President of the United States was also requested to cause the longitude of the Capitol to be determined as exactly as possible by further observations, but the resolution was not carried into effect until after further Congressional action in 1821, when Mr. Lambert was appointed by the President "to make astronomical observations by lunar occultations of fixed stars, solar eclipses, or any approved method adapted to ascertain the longitude of the Capitol from Greenwich."

Mr. Lambert's report, which was submitted to Congress by President Monroe on January 8, 1822, gives determinations of the longitude of the Capitol referred to Greenwich and Paris, and the longitude of the President's house referred to Greenwich, and strongly urges the importance of establishing an observatory.

A first supplementary report by Mr. Lambert, dated March 7, 1822, corrects the longitude of the Capitol previously given. The old value is returned to, however, in a second supplementary report communicated by the President December 23, 1823, in which further arguments are made in favor of establishing an observatory. This was reported upon in 1824, but the report laid upon the table. No further action was taken at this time.

No stronger or more persistent advocate of the establishment of a national observatory can be found than John Quincy Adams, who as early as 1823 offered $1,000 to Harvard University on condition that an astronomical observatory be established, and in 1825, as President of the United States, in recommending the foundation of a national observatory, remarked: "Connected with the establishment of a university, or separate from it, might be undertaken the erection of an astronomical observatory, with provision for the support of an astronomer, to be in constant attendance on the phenomena of the heavens, and for the periodical publication of his observations." He alluded, "with no feeling of pride," to the fact that "on the comparatively small territorial surface of Europe there are existing more than one hundred and thirty of these light-houses of the skies; while throughout the whole American hemisphere there is not one."

This recommendation, so far as it relates to an observatory, was referred to a committee, which reported with regard to the position, the probable cost of building, and the expense of equipping and maintaining the observatory. It was advised that a site be chosen within the city of Washington, and pointed out that "the astronomer should be independent in the performance of his duties, but accountable for the results, for his industry, and the correctness of his observations and calculations." It was further remarked that, "as an astronomer, with the requisite talents and qualifications, would be obliged to devote all his time and attention to the duties of his station, it is not to be expected that a fit person could be procured for this situation without the compensation of a liberal salary." The report, which was drawn up by Major-General A. Macomb, Chief of Engineers, and submitted to the Secretary of War, was accompanied by other documents relative to the site of the proposed observatory and details of a plan for a building.

This report, together with "a bill to establish an observatory in the District of Columbia," reached a second reading in Congress, but did not advance beyond this point.

No further action was taken until 1830, when Mr. Branch, Secretary

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of the Navy, expressed his approval of the project of founding a national observatory. He believed it to be particularly desirable for the purpose of establishing a first meridian and for the prosecution of purely scientific work, such as the determination of the figure of the earth and the improvement of theories relative to the motions of planetary bodies. Commodore John Rodgers, writing on the same occasion to the Secretary of the Navy, considered the principal object in establishing the observatory "would not be to aid, essentially, the surveying of our coast, but to unite our enterprise and efforts with those of other enlightened countries; in advancing, generally, the service of astronomy * * * and to furnish annually our naval and commercial interests with a correct ephemeris."

In 1835 Mr. Dickerson, Secretary of the Navy, reported in favor of establishing a national observatory, which he considered should be charged, among other things, with the duty of keeping maps and charts, regulating chronometers, and preserving mathematical and philosophical instruments required for the naval service.

In 1838, when Richard Rush, our minister to England, announced the successful termination of the friendly suit entered by the United States for the purpose of securing the Smithson legacy, ex-President Adams was one of those of whom the Secretary of State, by direction of the President, requested advice regarding the proper application of the bequest. He immediately urged the establishment of a great astronomical observatory "equal to any in the world." In fact he continued to be the most ardent supporter of the plan of establishing a national observatory and never ceased his advocacy of it in Congress and in the public prints until an observatory had been founded in connection with the Navy. A resolution proposed by Mr. Adams in the House of Representatives from the committee on January 26, 1839, provided that "the first appropriations from the interest or income of the Smithsonian fund ought to be for the erection and establishment, at the city of Washington, of an astronomical observatory, provided with the best and most approved instruments and books, for the continual observation, calculation, and recording of the remarkable phenomena of the heavens, for the periodical publication of the observations thus made, and of a nautical almanac, for the use of the mariners of the United States and of all other navigating nations." This was presented in connection with House Bill No. 1161, Senate Bill No. 293, providing for the establishment of an astronomical observatory.

With characteristic persistence Mr. Adams introduced his bill for the establishment of a national observatory in the Twenty-sixth Congress, and presented with it a long report on the importance of astronomical work. This met with no better success than his previous efforts. The discussion as to the disposition of the Smithson bequest continued, and a bill was introduced in the Twenty-seventh Congress by Mr. Adams, as chairman of a House committee on the Smithsonian Institution, providing for the erection of an observatory and the publication of the Smithsonian Almanac. The observatory bill was also presented by Mr. Adams to the Twenty-eighth Congress, 1843 to 1845, but not acted upon. It was not until after the act of incorporation by which the Smithsonian Institution was established had been formulated by the Twenty-ninth Congress, 1845 to 1847, that Mr. Adams was willing to cease his advocacy of a Smithson astronomical observatory. Prior to this time the Naval Observatory had been organized.

It should be pointed out, as Mr. Adams's position in the matter has sometimes been misunderstood, that he did not advocate the application

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of the entire Smithson fund to the establishment of an astronomical observatory, but merely expressed the desire that the income for seven successive years should go to found an observatory. He considered that the income later should be appropriated "to promote establishments for increasing and diffusing knowledge among men."

Under authority of the Navy commissioners, granted December 6, 1830, Lieutenant L. M. Goldsborough established in that year a bureau for the care of the charts and instruments of the Navy. At this bureau, which was located in the western part of the city of Washington, Lieutenant Goldsborough and the other officers connected with the depot of charts and instruments regularly rated all chronometers belonging to the Navy, for some months by sextant and circle observations and later with a 30-inch transit instrument made by R. Patten. This instrument was mounted in a small circular building on a pier extending 20 feet below the surface. In his report of February 7, 1845, from which most of these facts are derived, Lieutenant Gilliss remarks: "To Lieutenant Goldsborough, therefore, is due the erection of the first astronomical instrument for the Navy at Washington."

In 1833 Goldsborough was succeeded by Lieutenant Wilkes, who removed the office to a site proposed originally by Hassler in 1816, about 1,000 feet north, 5° west, from the dome of the Capitol. Here an observatory 16 feet square was erected by Wilkes at his own expense, and in it was mounted a 5-foot Troughton transit, made for the Coast Survey in 1815. This depot regularly supplied all United States vessels with chronometers and other instruments and charts. No systematic observations were made at this period, however, except those for the determination of time.

Lieutenant Gilliss, to whose influence the later development of the Observatory was in large measure due, first became a member of the staff in November, 1836, when he was ordered as assistant to Lieutenant Hitchcock, who was in charge during Lieutenant Wilkes's absence in Europe. In the following spring Gilliss was placed in charge, and immediately took up active observational work. During the absence of the United States Exploring Expedition (1838–1842), of which Lieutenant Wilkes was in command, Gilliss made a long series of observations of moon culminating stars, occultations, and eclipses for the determination of the differences of longitude between the depot and the stations occupied by the expedition. The results, which were published in 1846 under the title, "Astronomical observations made at Washington under order of the Secretary of the Navy dated August 13, 1838," are evidence of the enthusiasm and energy with which Gilliss carried his instructions into effect. With the considerable addition to the instrumental equipment which the instructions prepared by Lieutenant Wilkes had enabled him to make, Gilliss recorded over 10,000 transits of the moon, planets, and about 1,100 stars, and annually observed an average of 110 culminations of the moon and about 20 occultations. He also determined the right ascensions of 1,248 stars, which were published in a volume of 671 pages in 1846. He further recommended that provision be made for magnetic and meteorological observations, and this having received the approval of the Secretary of the Navy, a small frame building was erected for the purpose. Descriptions of the instruments and the results obtained with them were published in the tenth volume of the Senate documents of 1844–45.

Gilliss's admirable work stands in strong contrast with that of his immediate successor. It was due directly to Gilliss's influence that a new observatory of a permanent character was established in 1842. A

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recommendation to this effect, made by Gilliss to the Navy commissioners, was reported upon favorably, and a request for an appropriation was made by the Secretary of the Navy in his report to the President in December, 1841. In Congress the matter was not acted upon immediately, but after Gilliss had persuaded a skeptical member of the House Naval Committee to visit the old depot a unanimous report in favor of the plan was adopted. The Senate committee was less interested, but the rediscovery by Gilliss of Encke's comet attracted the attention of some of the members and led to the passage of the bill. In the House favorable action was secured at the last hour of the session of 1841–42. The bill adopted by Congress reads as follows:

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of the Navy be, and he is hereby, authorized to contract for the building of a suitable house for a depot of charts and instruments of the Navy of the United States, on a plan not exceeding in cost the sum of twenty-five thousand dollars.

SEC. 2. *And be it further enacted,* That the sum of ten thousand dollars be, and the same is hereby, appropriated, out of any money in the Treasury not otherwise appropriated, toward carrying this law into effect.

SEC. 3. *And be it further enacted,* That the said establishment may be located on any portion of the public land in the District of Columbia which the President of the United States may deem suited to the purpose.

Lieutenant Gilliss was accordingly directed by the Secretary of the Navy to consult various astronomers and to draw up plans for a building, an architect having been assigned to work under his direction. After a visit to Europe, where a number of instruments were purchased, Gilliss prepared the necessary plans and the work of construction was undertaken. Referring to Gilliss's report of November 23, 1843, on the progress of the work, the Secretary of the Navy said: "It is proper to remark that this building is adapted in form and structure not only for a depot of charts and instruments, but for an astronomical observatory." The bill passed by Congress did not specifically define the purpose of the "suitable house for a depot of charts and instruments of the Navy of the United States," nor did it assign to this depot any special function. The action of the Secretary of the Navy was based upon the report of the Naval Committee, which clearly indicated that the new "depot" was not intended merely as a storehouse of charts and instruments, but more particularly as an institution where investigations in astronomy, magnetism, and meteorology should be conducted. Astronomy was given the foremost place in the report, and it was evidently intended that the principal stress should be laid upon astronomical observations.

The site chosen for the observatory was one which Washington had selected as a suitable place for a national university. The height of the hill on which the building stood is surpassed by that of only one eminence in the city of Washington. It is in the southwestern part of the city and overlooks the Potomac from its north bank. The building was constructed with deep foundations for the walls and instrument piers, and the various details seem to have been worked out after careful consideration of the requirements. The instrumental equipment was selected after consultation with many astronomers at home and abroad. It comprised an equatorial telescope of 9.6 inches aperture by Merz & Mahler, of Munich; a meridian transit of 5⅓ inches aperture by Ertel, of Munich; a prime vertical transit of 4.9 inches aperture by Pistor & Martins, of Berlin; a mural circle with telescope of 4.1 inches aperture and circle 5 feet in diameter, by Troughton & Simms, of London, and a 4 inch comet seeker by Utzschneider & Fraunhofer, of Munich. The collection of magnetic instruments, purchased with the

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advice of Professor Lloyd and Colonel Sabine, consisted of a declinometer, a bifilar magnetometer, a balance magnetometer, and a Fox deflector, all by Barrow, of London. The meteorological instruments included a standard barometer, dry and wet bulb and self-registering thermometers, hygrometer, anemometers, and rain gauge. Seven hundred volumes of standard works were purchased for the library, and numerous gifts of books were received from learned societies and observatories in Europe.

The new Observatory, as the result of Gilliss's untiring labors, was completed and ready for use at the end of September, 1844; but unfortunately for the progress of astronomy in the United States, the man whose exertions had given to the country a national observatory was not permitted to direct its operations. Regardless of the fact that the scientific interests of an observatory equipped for astronomical research can not be expected to prosper unless they are entrusted to the directive control of an astronomer, the naval authorities preferred to appoint a brilliant hydrographer to a post which neither his training nor sympathies had prepared him to fill. Gilliss, an able astronomer, with the best interest of his profession at heart, was ordered to duty elsewhere, while Lieutenant Matthew F. Maury, who had been compelled by a recent accident to retire from active naval service afloat, was placed in charge of the new Observatory. Referring to his appointment to the superintendency, Maury says in a letter preserved in his biography:

> You know I did not want the place, and only decided to keep it when I heard it had been promised to a civilian, under the plea that no one in the Navy was fit for it. I then went to Mason, pronounced that the repetition of a practical libel, and told him he must stand by me. He did so, and though I had never seen an instrument of the kind before, and had no one with me who had, I was determined to ask no advice or instruction from the savans, but to let it be out and out a Navy work. Under these circumstances you may well imagine the pleasure which I derive from any fresh proof of success. (Life of M. F. Maury, by his daughter, p. 50.)

It must not be understood from this reference to an important event in the early history of the Observatory that Maury's ability as a man of science is intended to be called in question. His success as a hydrographer and his remarkable energy in securing material for his celebrated work on the Physical Geography of the Sea are known throughout the civilized world. Decorated by learned societies and foreign governments, and consulted by his ablest contemporaries regarding the numerous subjects which had received his attention, he may well be regarded as one of the great scientific leaders of his time. But in any historical sketch of the Naval Observatory it is impossible to omit some word of comment regarding the practice of appointing to difficult posts men whose claim to preferment is based solely on some notable achievement in another and very different field of action. In the Naval Observatory the effects of this policy were serious and lasting. Had Gilliss been permitted to retain his well-earned position as director it is not improbable that the institution would have developed into a national observatory of the first rank. Maury attempted a task far beyond the capacity of the Observatory. Its failure cast a cloud over the formative period of the work and sadly reduced the chances of future success. Had Maury been content to adhere to his original scheme, which included systematic meridian observations of the sun, moon, planets, and moon-culminating stars, regular observations of α Lyræ and the determination of the declinations of a catalogue of zenith stars with the prime vertical transit, and a review of the double stars of the Dorpat Catalogue with the equatorial telescope, valuable results

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might have been obtained. But this programme, entered upon in 1845 and respected for a few years, was soon abandoned. After 1850 but few meridian observations were recorded, and the work with the prime vertical transit was given up at about the same period. In 1846 Maury had described, in a letter to Mr. George Bancroft, Secretary of the Navy, his far-reaching scheme of star cataloguing.

> To this end a regular and systematic exploration of the whole heavens from 45° south has been commenced, with the intention of penetrating with the telescope every point of space from that parallel of declination up to the north pole, and of assigning position to every star down to the tenth magnitude that shall pass through the field of view.

It was, indeed, proposed to catalogue not only the positions of all stars visible with the instruments, but their magnitudes and color as well. The task was thus far more extensive than that which the Astronomische Gesellschaft, in preparing, twenty years later, for the revision of Argelander's Durchmusterung, assigned not to a single institution, but to more than a dozen observatories scattered throughout the world.

For four years the observational work for Maury's catalogue was continued, and during this time some 38,000 unreduced observations were accumulated. The greater part of these were made by inexperienced observers, for the system had by this time become established of detailing naval officers for short periods of shore duty at the Observatory. These men, skilled in the execution of their duties at sea, but naturally for the most part lacking in practical acquaintance with observatory work, might have become good observers if allowed to remain long enough at their new posts. But unfortunately for the results they were generally hurried back to sea before they could acquire any serious idea of observational practice. The meridian circle zones observed in 1846 were published by Maury in 1860, but the remaining zone work was not printed until 1873, when it was brought out under the supervision of Professor Asaph Hall, who says of it:

> On account of the inexperience of some of the observers and the lack of good organization, these observations contain many errors, and the whole work needs a careful revision.

This revision, though undertaken in accordance with a plan prepared by Professor Hall, has not yet been completed. In his account of the Naval Observatory, published in Science (January 6, 1899), Professor Skinner has contrasted Maury's colossal undertaking and its failure with the great success achieved by Argelander, of the Bonn Observatory, who, during the period 1850–1860, observed and published the approximate positions of 324,000 stars of the first nine magnitudes between 2° south declination and the north pole. As Professor Skinner remarks:

> Maury failed because his scheme was entirely too herculean to be accomplished with the means at his command, while Argelander achieved success by bringing the scope and precision of his work within the limits possible of execution.

Lieutenant Maury should receive credit for the support he gave to Walker and other astronomers at the Naval Observatory, who, contemporaneously with Bond, of Cambridge; Mitchell and Locke, of Cincinnati, and Saxton, of the Coast Survey, worked out the chronographic method of registering star transits. The method was employed by Lieutenant Wilkes as early as 1844 in determining the longitude of Baltimore, and prior to 1846 it was brought into practical use at the Naval Observatory. The magnetic clock, fillet chronograph, and cylinder chronograph used a few years later at the Observatory were furnished

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by Dr. Locke, of Cincinnati, and paid for from an appropriation by Congress of $10,000, secured by Maury for this purpose in 1849.

But while most of the systematic astronomical observations planned for the Observatory by the first Superintendent resulted in failure, it is fortunately possible to refer to certain successful pieces of individual work performed by members of the staff. The most conspicuous of these is the discovery by Sears Cook Walker that the planet Neptune had been observed by Lalande at the Paris Observatory some fifty years prior to its detection by Leverrier and Adams. Certain stars recorded by Lalande were found to be identical with the new planet, and it thus became possible to at once determine the elements of its orbit with a high degree of precision. Mr. Walker was at that time the only civilian astronomer attached to the staff. His ability and experience would doubtless have continued to be of great use to the Observatory, but unfortunately, as the result of personal differences with Maury, he was led to resign after serving only fourteen months.

The remaining professional astronomers on the staff were drawn from the corps of professors of mathematics of the Navy, which had been organized for an entirely different purpose.

By law of August 3, 1848 (Rev. Stats., secs. 1399–1401) the number of professors of mathematics in the Navy is not to exceed twelve, appointed by the President, by and with the advice and consent of the Senate, to "perform such duties as may be assigned them by order of the Secretary of the Navy at the Naval Academy and Naval Observatory and on board ships of war in instructing the midshipmen of the Navy or otherwise."

By law of May 21, 1864 (Rev. Stats., sec. 1528) it was provided that "three professors of mathematics shall be assigned to duty at the Naval Academy, one as professor of ethics and English studies, one as professor of the Spanish language, one as professor of drawing." All these professors of mathematics are life officers in the Navy, with relative military rank and the privilege of the retired list. (Rev. Stats., secs. 1480, 1481.)

When the Naval Academy was founded in 1845 it became unnecessary for the professors of mathematics to go to sea, and they were consequently available for other duties. Several members of the corps, including Professors Coffin, Hubbard, Keith, and Beecher, were attached to the staff of the Naval Observatory. Professor Coffin had previously served six years at sea, but Professors Hubbard and Keith took up their work at the Observatory immediately after appointment. The principal work assigned to them was that of making Maury's proposed catalogue with the mural and meridian circles and the transit instrument. Observations of the zones were carried on between the years 1846 and 1849. All these observations were reduced subsequent to 1862 by Dr. B. A. Gould, of Cambridge, Mass. It is the individual work of these members of the staff, however, which particularly deserves mention. This includes Coffin's expansion of Bessel's refraction tables, Walker's investigation of the latitude of the Observatory and his study of standard thermometers, and tables prepared by Coffin, Keith, and Hubbard for the reduction of apparent to mean star places. All these pieces of work were creditably performed.

A civilian astronomer at the Observatory during the greater part of Maury's administration was Mr. James Ferguson, appointed assistant observer in 1848. To him was assigned the equatorial telescope, and it was assiduously employed, especially in the observation of asteroids, of which three were discovered by Ferguson.

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Many line officers were ordered to duty on the staff, but their terms of service were much too short to permit them to contribute in any important way to the work of the institution. The following table, taken from Washington Astronomical Observations, 1851–52, will serve to give an idea of the rapidly changing character of the working force:

Terms of service of officers during 1851–52.

Name.	Year.	Months.	Days.
Lieut. George Minor	.....	1	28
Lieut. B. M. Dove	1	.....	17
Lieut. Henry Walke	.....	.....	12
Lieut. D. B. Ridgely	.....	5	14
Lieut. William T. Muse	.....	4	11
Lieut. Charles Steedman	.....	10	27
Lieut. Richard Forrest	1	9	13
Lieut. William H. Ball	.....	10	7
Lieut. J. Humphreys	.....	3	20
Lieut. O. H. Berryman	.....	11	6
Lieut. H. N. Harrison	.....	1	.....
Lieut. W. Ross Gardner	1	9	25
Lieut. John Contee	1	.....	22
Lieut. James D. Johnston	.....	11	16
Lieut. Isaac N. Brown	.....	.....	11
Lieut John L. Worden	1	2	17
Lieut. Charles E. Fleming	.....	1	8
Lieut. John Q. Adams	.....	.....	5
Lieut. W. C. B. S. Porter	.....	10	6
Lieut. Van R. Morgan	1	3	29
Lieut. E. L. Winder	.....	1	2
Lieut. George B. Balch	1	1	17
Lieut. J. S. Kennard	1	2	18
Lieut. J. M. B. Clitz	.....	1	26
Lieut. J. C. Beaumont	.....	3	9
Lieut. W. B. Fitzgerald	.....	8	23
Passed Midshipman R. Aulick	.....	3	25
Passed Midshipman George P. Welsh	1	1	4
Passed Midshipman A. F. Warley	.....	4	18
Passed Midshipman Colville Terrett	1	1	10
Passed Midshipman C. H. Wells	.....	6	19
Passed Midshipman J. H. Carter	.....	5	12
Passed Midshipman A. C. Jackson	1	.....	21
Passed Midshipman John J. Hanson	.....	10	9
Passed Midshipman W. D. Whiting	.....	2	.....
Passed Midshipman T. L. Walker	1	.....	20
Passed Midshipman John M. Brooke	.....	3	18
Passed Midshipman O. C. Badger	.....	1	9
Passed Midshipman R. D. Minor	.....	8	1
Passed Midshipman N. H. Van Zandt	.....	9	1
Passed Midshipman William M. Gamble	.....	9	16
Passed Midshipman T. S. Fillebrown	.....	9	17
Passed Midshipman Dawson Phenix	.....	2	6
Passed Midshipman R. F. R. Lewis	.....	8	19
Passed Midshipman A. W. Johnson	.....	1	13
Total	29	4	27

It will be seen that the average term of service in the case of these officers was less than eight months.

Up to August 31, 1862, the Observatory was a part of the Bureau of Ordnance and Hydrography. The first volume of publications, which appeared in 1846, contains two title-pages, one of them printed as a part of the volume, the other engraved and separately inserted. The regular title page designates the institution as "The National Observatory." The engraved title-page, which was apparently prepared and inserted by direction of Lieutenant Maury, gives the name as "The U. S. Naval Observatory." Volumes II and III, published in 1851 and 1853, each contain two title-pages, both bearing the name "The National Observatory." In 1854 Lieutenant Maury stated, in a letter addressed to Commodore Charles Morris, Chief of the Bureau of Ordnance and Hydrography, that "the Observatory was christened "National" by

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Mr. Bancroft (Secretary of the Navy under President Polk) in a letter of March 6, 1846, relating to the labors to be undertaken at the National Observatory. Its Observations (first volume) were published under that title by his authority, and not by that of the Bureau." On December 11, 1854, Commodore Morris appealed to Secretary of the Navy J. C. Dobbin, who, on December 12, 1854, ruled as follows: "My opinion is that it (the Observatory) should be styled 'The United States Naval Observatory and Hydrographical Office.' It has always been under the control of the Navy Department; it is conducted by Navy officers, both in its superintending and somewhat subordinate duties. It is a Navy affair, and its reputation is the property of the Navy. If it assume another name and character, the next step will be to place a civilian at its head."

Under the superintendency of Lieutenant Maury the astronomical work of the Naval Observatory was soon almost altogether replaced by purely hydrographical investigations. With the exception of Professor Yarnall (appointed professor of mathematics in 1839, made a member of the staff of the Observatory in 1852), who observed regularly with the mural circle from the year 1853, and Mr. Ferguson, who carried on the work with the equatorial, practically the entire staff was employed in the preparation of wind and current charts. Lieutenant Maury, who had planned these charts, devoted himself with great vigor to their preparation. He reports that often in connection with this work "almost the entire corps were ordered to sea at a moment's warning."

It has sometimes been said of the Observatory that it was established for the purposes of the Navy, and that its astronomical work is only incidental and not of prime importance. Such a view could hardly have been held by Lieutenant Maury when he drew up his far-reaching plans for astronomical research, which were certainly calculated to absorb by far the greater part of the energies of the staff. As a matter of fact the staff was not nearly adequate to complete even these purely astronomical investigations, not to speak of additional hydrographical labors. The extensive instrumental equipment of the Observatory, which for the most part has no connection with naval work, is further evidence that the institution was planned and equipped from the very outset for astronomical investigations similar to those of other national observatories.

Professor Yarnall's catalogue of stars, which was in process of preparation during this period, was finally completed and published in 1878.

The resumption of astronomical work was made possible when, on April 26, 1861, Lieutenant Maury suddenly left the Observatory to join the forces of the Confederate States.

A successor to the superintendency was immediately found in Captain J. M. Gilliss, through whose efforts the Observatory had been founded twenty years before. With a keen appreciation of the importance of the work for which the Observatory had been planned, he caused the staff to devote its attention principally to astronomical observations, though the exceptional needs of the naval service at that period were not neglected. The prompt publication of results, including those of magnetic and meteorological observations, was considered by Gilliss to be of great importance, and in spite of the delays due to the civil war, the volumes for 1861 and 1862 were published in 1862 and 1863, respectively. Arrangements were also made for bringing up the arrears of publication, and the necessary reductions were intrusted to Dr. B. A. Gould. On August 31, 1862, a law was passed for the reorganization of the naval bureaus, and by provision of this law the

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Observatory was transferred from the Bureau of Ordnance and Hydrography to the Bureau of Navigation. It remained in this Bureau until July 1, 1889, when it was transferred to the Bureau of Equipment.

During the brief period of Gilliss's superintendency much was done to improve the condition of the Observatory. The astronomical staff, greatly strengthened by the appointment of Professors Newcomb, Hall, and Harkness in 1861 and 1863, was for the first time able to devote itself without serious interruption to the work of research. The volume of publications for 1862 contained, in addition to the routine observations, a discussion of the longitude of Washington by Professor Newcomb, and a paper on Comet II, 1862, giving drawings by Professor Harkness, and equatorial observations by Professor Hall. The volume for 1863 included, with other matter, an investigation of the solar parallax, based on observations of Mars by Professor Hall and Mr. Ferguson. These special investigations were supplementary to the routine observational work on the sun, moon, planets, and stars, which had been reestablished by Gilliss.

The rapidly increasing number of minor planets, which in 1863 had reached 75, led Gilliss, who wished to share with the Greenwich Observatory the labor of observing them regularly, to present to Admiral Davis, Chief of the Bureau of Navigation, a statement of the need of a new transit circle of adequate optical power. The request was immediately granted, and the new instrument contracted for in 1863. Unfortunately, however, Gilliss did not live to see the completion of the transit. He died suddenly on February 9, 1865, after directing the Observatory for a period of less than four years.

In 1847 Congress enacted that the superintendent of the Observatory should be either a captain, a commander, or a lieutenant in the Navy. This was repealed by an act of Congress approved March 3, 1865, very shortly after the death of Gilliss, which did not specify the rank of the naval officer employed as superintendent. The substitution of a civilian for a naval head, which was strongly urged at that time, was rendered unnecessary by the appointment on April 28, 1865, of Rear-Admiral C. H. Davis, at once a naval officer of high rank and a man acquainted with the highest theoretical astronomy of his day. Admiral Davis had formerly been Superintendent of the American Ephemeris and Nautical Almanac and was fitted by his tastes and training for the position he was now called upon to occupy. He immediately took up the work of his predecessor and successfully carried it forward. In October, 1865, the Pistor and Martens meridian circle of 8.52 inches aperture, which had been ordered by Gilliss, was mounted at the Observatory. A thorough study of the instrument, including a determination of the division errors of its circles, was made and published by Professor Simon Newcomb. Admiral Davis, in commenting on the new meridian circle, expressed great satisfaction that the Observatory was at last "in possession of a circle with which we can measure right ascensions and polar distances at the same moment and with equal exactness." This was indeed a point of some importance, especially since, owing to the absence of a well-defined plan of work, the simple transit used in Maury's time for the right ascension and the mural circle employed for the declination appear to have been worked without reference to each other.

On account of its connection with the Hydrographic Office, the Observatory was called upon by a Senate resolution dated March 19, 1866, to prepare a report on the various proposed lines for interoceanic canals and railroads across the Isthmus of Panama. On June 21, 1866, in

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consequence of the organization of the United States Hydrographic Office, the various charts, sailing directions, and nautical instruments (except chronometers), were removed from the custody of the Observatory. Most of this material was returned however in 1883. Since that time the Observatory has had charge of all nautical instruments belonging to the Navy, except charts and compasses.

Admiral Davis's superintendency was brought to a close on May 8, 1867, when he was ordered to take command of the South Atlantic squadron.

By this time the Observatory had in some measure recovered from the state into which it had fallen during Maury's administration. On account of the successful work of its staff, and especially in view of the brilliant individual investigations of some of the members, the institution had acquired an enviable reputation at home and abroad. The fears that had been entertained by various American astronomers that naval officers would not be qualified by their training to discharge the duties of superintendent, while realized in the case of Maury, were relieved during the administrations of Gilliss and Davis. At the close of the civil war many noted officers, whose conspicuously able service had brought them well-deserved reputations, were available for shore duty. These gentlemen were not trained astronomers, and the advance of practical astronomy during the preceding twenty years had been so rapid as to prevent any but trained astronomers from coming into close touch with the subject. On the other hand, the training required in the Navy was no less severe in its demands or special in its aims. Here also a short period of time had seen great advances, for steamships had come into use and the transition from the old sailing vessel to the modern battle ship was already more than half accomplished. Thus an acquaintance with the methods and problems of practical astronomy, which the less exacting demands of the naval service during the first half of the century had given more leisure to acquire, was denied to the better-trained officers of the later period. They could not reasonably be expected, therefore, to carry out successfully all the exacting duties which must devolve upon the director of a great observatory. The preparation of a suitable plan of work for a national observatory and the provision of means and methods for its successful prosecution is a problem calculated to tax the powers of the ablest and most experienced astronomer. But it is nevertheless the chief duty of the director of an observatory, and if not fulfilled the results which might reasonably be expected can never be attained.

It is evident, therefore, that a critical period in the history of the Observatory had now been reached. Thanks to the initiative of Wilkes and Gilliss, and the subsequent labors of Gilliss and Davis, the Observatory had in some measure accomplished the purposes of a national institution. Up to this time, except under the administration of Maury, it had been directed by men who had devoted much time and attention to the study of astronomy. It was now to come under the control of a line of distinguished officers, brilliant and accomplished in their profession, but (with the exception of Admiral Davis, who was again in charge from 1874 to 1877), without extensive experience in astronomical research.

Rear-Admiral B. F. Sands was appointed Superintendent on May 8, 1867. He had seen a brief term of service as an assistant at the Observatory in its earliest days, but his subsequent duties had left him no opportunity to become an experienced astronomer. While he was, therefore, unprepared to plan and personally supervise the astronomical

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work, he nevertheless showed his appreciation of the fact that the Observatory was primarily intended for astronomical research by inducing Congress to appropriate $50,000 for the construction of a 26-inch telescope. The members of the Observatory staff were expected to plan and carry out their investigations, while the superintendent devoted himself to purely administrative duties. In a private institution the plan of leaving astronomers to themselves to conduct independent researches need not prove altogether unsuccessful, though not calculated to assure the highest degree of efficiency. At this Observatory it resulted in the publication of various able individual investigations, but not in the production of a well-planned and well-executed series of observations such as must be expected from a national institution. For from its very nature and the resources at its disposal a government observatory should be devoted to the prosecution of investigations of a routine character, extending over long periods of time, and consequently beyond the reach of the great majority of private establishments.

Admiral Sands's administration was marked by the publication of many valuable results and the initiation of several undertakings of importance. The appropriation for a 26-inch refractor has already been referred to. The telescope was ordered from Messrs. Alvan Clark & Sons in 1870 and completed in November, 1873. This instrument has yielded excellent results, notably in the observation of double stars and the discovery and measurement of the satellites of Mars. A new and improved observing room for the transit circle was erected in 1869. The plan of distributing time signals by telegraph, introduced into the Naval Observatory by Professor Harkness in 1865, was extended and improved by the adoption of automatic apparatus devised by Professor Eastman. Expeditions were sent to observe the total solar eclipses of 1869, 1870, and 1873. The longitudes of numerous stations in the United States and Europe were determined. Observations of the sun, moon, and planets and of selected lists of stars were made with the transit circle, but there was a marked absence of continuity in this department of the Observatory. The important work of determining corrections to the places of the standard stars used in the Ephemeris was discontinued. Professor Yarnall employed the mural circle for the purpose of completing his catalogue. Professor Newcomb devoted great attention to theoretical work, especially in connection with his theory and tables of the moon. The meteorological observations were continued under the supervision of Professor Eastman. Extensive preparations were made at the Observatory for observing the transits of Venus of 1874 and 1882. The transit commission consisted of the Superintendent of the Observatory, the president of the National Academy of Sciences, the Superintendent of the United States Coast Survey, and Professors Newcomb and Harkness. Most of the work was done by these two astronomers, who were called upon to devote to this service time which could otherwise have been given to their regular duties at the Observatory.

The return of Admiral Davis to the Observatory on February 16, 1874, after the retirement of Admiral Sands, had contributed in no small degree to the output of work. Admiral Davis remained in charge until his death, which occurred on February 18, 1877. It was in this year, after the appointment of Rear-Admiral Rodgers to the superintency, that the principle of leaving the observers to plan for themselves, which had previously been in vogue, was submitted to the

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members of the staff for discussion. It had been suggested to Secretary Welles, by various persons who recognized the need of a directing head for the astronomical work, that a civilian astronomer be placed in charge. Similar suggestions were offered to Secretary Thompson in 1877, and he accordingly requested Admiral Rodgers to obtain the views of the members of the Observatory staff. Accordingly Admiral Rodgers invited the opinions of the astronomers regarding two questions:

(1) Whether the Observatory should remain under the control of the Navy Department.

(2) Whether it is more advantageous that the Superintendent of the Observatory should be a line officer of the Navy or a practical astronomer.

A majority of the professors, including Professors Yarnall, Hall,[1] Harkness, Nourse, and Eastman, united in a letter to the Superintendent, which contained the following statements:

Furthermore, there are few eminent astronomers who have not made their reputations by the cultivation of some specialty to the exclusion of almost everything else, and were such a man made Superintendent of the Observatory there would be great danger that the whole force of the establishment would be employed in advancing his specialty; thus preventing his assistants from engaging in other work of equal or perhaps greater importance, and greatly limiting the scope and usefulness of the institution.

Were the Observatory transferred to the civil service it would lose the immense advantages which it now derives from its naval organization, and its scientific success would be endangered by the evils which are inseparable from a service subject to political influences. The expenses of the institution would also be largely augmented, because it would then have to pay for labor which is now performed by the line and staff officers of the Navy.

It may not be improper to mention that, with a single exception, the success of observatories managed by civilians in the United States has not been such as to encourage a trial of their system; and we regard it as certain that the withdrawal of naval discipline from this institution would be a serious detriment.

In view of these considerations we are of the opinion that—

First. The Observatory should remain attached to the Navy Department, that being the branch of the Government to which it most naturally belongs.

Second. The Superintendent of the Observatory should be a line officer in the Navy, of high rank, whose duty it should be to look after the business affairs of the institution, thus leaving the scientific corps leisure for their proper work.

Third. We think the plan introduced by the present Superintendent, Rear-Admiral John Rodgers, of holding a monthly meeting of the officers of the Observatory, at which all the operations of the institution are discussed, is a most excellent one.

In reading this letter it should be remembered (1) that at the time it was written there was but one large observatory in the United States in addition to the Naval Observatory, while the others, though with small means, have done excellent work; (2) that the system of managing observatories by civilian astronomers was not special to the United States, but had been followed in all civilized countries, and (3) that the danger referred to in the first paragraph had not been realized in other national observatories.

[1] In a letter dated April 23, 1892, addressed to Senator Hale, of the Senate Naval Committee, Professor Hall says: "My term of service at the Naval Observatory extended from 1862 to 1891, first as an aid or assistant astronomer, and afterwards as a professor. During this period the Observatory had twelve Superintendents, all of them line officers of the Navy. Some of these gentlemen were very able and distinguished men, although but few of them had more than a general knowledge of astronomy. My relations with the Superintendents were pleasant, and I have no complaint to make of lack of opportunity to do astronomical work. Still, the frequent change of Superintendent and his want of technical knowledge are defects in the present system." (Senate Mis. Doc. No. 206, Fifty-third Congress, second session.)

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One member of the staff, Professor Newcomb, expressed his views in the following terms:

I am of the opinion that it (the Observatory) should remain under the control of the Navy Department, be the depot of naval chronometers, and have the same relation to the Navy Department that the Greenwich Observatory bears to the Admiralty of England.

In regard to the second point, I am of the opinion that the establishment should have a scientific head for these reasons:

1. The generally recognized necessity that every office should, so far as practicable, be under a head professionally acquainted with its routine of business, exists here. The most important duty of the Superintendent is to see that the observations made and the work performed are those most advantageous for the objects with which the institution was founded; that the calculations are correctly made, and that harmonious cooperation is secured among the various departments. The securing of these objects requires a permanent policy, which can only be inaugurated by a scientific head. As illustrative of this view, I may cite the fact that during one-fourth the existence of the Naval Observatory the publication of the annual volumes of observations was entirely omitted, for the reason that only one or two observers made any observations worth publishing. The most important want of national astronomy at the present time is general tables of the stars and planets corresponding to the present state of practical astronomy, and it is a want which can, in its full extent, be supplied only by a large and well-organized observatory, securing the cooperation of many minds in the work of observation and calculation. I am unable to see how such a work as this can be successfully executed, except under constant scientific supervision of the establishment.

2. It seems to me that a new observatory should be built and administered with some one or more well-defined objects in view, and that these objects should be those of the fulfillment of which science stands most in need. Scientific control in some form would, I think, at least tend to assure the public that this end was being secured, though it might be executed by a commission or a board as well as by a single person.

The board established by Rear-Admiral Rodgers, and referred to in the letter signed by the majority of the astronomers, consisted of the Superintendent, the line officer next in rank to the Superintendent, and the senior professor of mathematics. It remained in existence for two or three years, but was subsequently discontinued.

Had the staff at this period been composed of men of only average ability, it is hardly likely that it would have been left so long without a well-defined plan of work to pursue. But the brilliancy of the individual achievements of its members brought them international reputations, which were shared by the Observatory. Thus the absence of a continued and homogeneous series of routine observations, such as a directing astronomer would have planned, was overlooked by the immediate authorities.

A few years later Commander (now Rear-Admiral) W. T. Sampson was ordered to duty at the Observatory as aid to Vice-Admiral Rowan, then Superintendent. As a result of a controversy which arose between the civilian and naval members of the staff, considerable discussion was aroused. Commander Sampson's view was expressed in a letter to the New York Herald (February 20, 1883), which contains the following paragraph:

When I came here on duty, a little more than a year since, I found these instruments disused. The transit instrument had not been used since 1878, and then only at intervals for several years previous. The mural circle had not been used since 1877. The prime vertical had not been used since 1867. These instruments had been shamefully neglected and much injured thereby. The prime vertical had received further injury by an incompetent observer. The small equatorial and comet seeker were in the same disgraceful condition and unfit for any real work.

Someone was clearly at fault. Commander Sampson believed the members of the staff to be inefficient and accordingly placed the transit and prime vertical in the hands of lieutenants of the Navy. The astronomers seriously criticised him for this action, and under the circumstances it is not surprising that there was considerable difference

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of opinion among those who took part in the discussion. It does not appear that Commander Sampson claimed for the lieutenants superior ability as observers, though he considered them competent to undertake this and other work. But he did believe that the instruments should be used, and he accordingly took steps to bring them into service.

Commander Sampson's letter goes on to show that the Navy has numbered among its officers many astronomers of ability. Speaking of the bill then recently introduced into Congress, which provided that "hereafter the Superintendent of the Naval Observatory shall be a professional astronomer of established reputation," he expresses his belief that "any reasonable man might indorse such a proposition." He further remarks that "the only naval officers who consider themselves at the same time professional astronomers are the professors of mathematics at the Observatory and Professor Newcomb, superintendent of the Nautical Almanac." In the absence of any provision by law for the salary of the Superintendent of the Observatory, unless he be a naval officer, it followed that the operation of the bill would be to render impossible the appointment of an astronomer from civil life. The bills introduced in the Senate and House were referred to the Committees on Naval Affairs, and no further action was taken.

The incident was of service, however, in attracting the attention of the Navy Department to the needs of the Observatory. In his annual report for 1883, Secretary Chandler concurs in the recommendation of the Superintendent, Rear-Admiral Shufeldt, "that provision be made for the appointment of a board of visitors, composed of a limited number of eminent astronomers, to examine annually into the condition of the Observatory and advise with the Superintendent upon the character of the work to be done, thereby removing many of the objections that are now urged against the administration of the institution."

The disadvantages of the old site of the Naval Observatory had been brought to public attention in 1877, when the necessity of removal was strongly urged. In 1880 Congress appropriated funds for the purchase of a new site and the preparation of plans for new buildings. A commission was also appointed to select a suitable site. The tract of land now occupied by the Observatory was purchased and the buildings were designed. In 1885 Secretary Whitney asked the opinion of the National Academy of Sciences "as to the advisability of proceeding promptly with the erection of a new Naval Observatory upon the site purchased in 1880." In the report of the Academy, transmitted to the Senate by the Secretary of the Navy in 1886, this question and that of the organization of the Observatory are fully discussed. After finding "no evidence of the kind of system which governs the operations of the Observatory, nor even evidence that such system exists at all," and pointing out the unsatisfactory state of the observations, the Academy recommended that the work of erecting the new Observatory, which they believed should be styled "National," should be undertaken without delay. The new institution should be under civilian administration, and to it should be transferred the astronomical instruments belonging to the old Observatory. Finally, it was recommended that the remaining instruments be transferred to the observatory at Annapolis, together with the books chiefly relating to navigation. This latter observatory should be enlarged if necessary and devoted solely to the wants of the naval service.

In a letter addressed to the committee of the Academy, Commodore Belknap, then Superintendent, stated that the Observatory "is first of all a naval institution, its astronomical work being, so far as the naval

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service proper is concerned, of a purely secondary consideration." The naval work was said by the Superintendent to consist of rating and testing chronometers, distribution to naval stations and branch hydrographic offices of daily noon signals, longitude comparisons with naval parties, inspection of nautical instruments, and the employment and training of naval officers.

The work of erecting the new Observatory was soon undertaken on a magnificent scale, but apparently the Superintendent's definition of the scope of its principal work was not accepted. As is shown more in detail elsewhere, the estimated value of the grounds, buildings, and instruments of the new Observatory is $856,547.35. If Commodore Belknap's statement were intended to be taken literally, it would appear that the greater part of this sum should have been applied in the provision of the equipment needed for the naval service. As a matter of fact, however, the cost of the buildings and instruments provided for this special purpose has been very small compared with the expenditure for the buildings and instruments designed for astronomical research. Further, the total annual cost to the Government of the work of the Naval Observatory is estimated to exceed $85,000, and not over a tenth of this can be charged to the expense of the naval duties. It must be concluded that the Naval Observatory is an astronomical observatory, built and equipped for astronomical research, but provided with the means required to render the Navy the services enumerated by Commodore Belknap. Moreover, from the very outset its successive superintendents have endeavored to conduct it as a National Observatory. Its continued support on so liberal a scale at the Government expense can be justified on no other grounds.

In 1891 the new buildings were nearly ready for occupancy. In his report for that year Mr. Tracy, the Secretary of the Navy, says:

> When the transfer and installment of the instruments are completed, the Government will be in possession of one of the most admirably equipped observatories in the world. The question of the proper administration of this important charge, representing one of the most important branches of scientific investigation undertaken by the Government, is one that demands early attention. The system in existence hitherto, by which the selection of the Superintendent has been confined to line officers of the Navy, subject like other officers to changes of duty at comparatively short intervals, prevents that continuity of administration which is essential in carrying on the work of a great national observatory. No programme of scientific investigation, especially in the department of astronomy, can be carried out successfully by any institution if liable to frequent interruptions by a change of its administrative head.
>
> I therefore recommend the adoption of legislation which shall enable the President to appoint, at a sufficient salary, without restriction, from persons either within or outside of the naval service, the ablest and most accomplished astronomer who can be found for the position of Superintendent.
>
> I would also recommend, in view of the era of progress and scientific development upon which the Observatory is now entering, that an advisory council be organized, composed of the Superintendent of the Observatory and its senior professor and of three other persons of scientific attainments, whose duty it shall be to consider and report upon new instruments and their proper installation; to draw up, with such changes as may be necessary from time to time, the programme of scientific work, including observation, reduction, and publication, and to make such inspections and reports as may be desirable in regard to the character of the work done by the Observatory.

On May 12, 1892, Senator Hale introduced in the Senate an amendment to the naval appropriation bill. This amendment, which had been prepared by Senator Chandler, reads as follows:

> For the expenses of a commission to be appointed by the Secretary of the Navy, to be composed of three naval officers of high rank, three eminent astronomers and three other civilians, to consider and report what is the most appropriate organization for conducting the astronomical work of the Naval Observatory, and what should be the scope and method of such work, the sum of two thousand dollars.

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This amendment was discussed by Messrs. Hale, Cockrell, Gray, McPherson, Chandler, Mills, and Allison, and agreed to. (Record, Fifty-second Congress, first session, pp. 4219–4221.) In the House all the Senate amendments were nonconcurred in, and the bill was sent to conference. In terms, the conference report, as finally adopted, read:

22. The Senate conferees recede from the amendment appropriating $2,000 for expenses of a commission to report on conduct, etc., of the Naval Observatory, and from the provision for such commission. (Record, pp. 5951–5952.)

In the same year a petition, asking that steps be taken to increase the efficiency of the Observatory, was signed by the great majority of American astronomers and presented to Congress by Senator Morrill. The House Naval Committee gave the petitioners a hearing, but reported adversely on the bill (House bill 3996) which had been introduced.

On June 9, 1894, Senator Morrill offered in the Senate the following amendment to the naval appropriation bill (H. R. 6748):

That from and after the passage of this act the Superintendent of the United States Naval Observatory shall be a person selected from civil life learned in the science of astronomy, to be appointed by the President, by and with the advice and consent of the Senate, and shall receive an annual salary of five thousand dollars; he may also occupy the dwelling house near the Observatory free of rent. The Superintendent aforesaid is hereby authorized and directed, with the approval of the Secretary of the Navy, to reorganize said Observatory establishment and to make such regulations as may be expedient in relation to the Observatory and its subordinate officers, professors, and other employees: *Provided*, That after January first, eighteen hundred and ninety-five, the total salaries and annual expenditures shall be adjusted to a basis of not exceeding fifty thousand dollars per annum.

This was referred to the Committee on Naval Affairs and ordered to be printed, together with letters from five of the leading astronomers of the United States, and other documents. The strength of this testimony, which was unanimously to the effect that the Naval Observatory had not made adequate return for the money expended, was such as to secure careful consideration of the question by Congress. Senator Morrill's amendment seems to have formed the basis of action in the Senate, but it was finally replaced by a similar amendment, prepared by the Secretary of the Navy, and favorably reported upon by the Committee on Appropriations. As finally passed by the Senate the bill provided for a "Director of Astronomy," to have charge of the astronomical work of the Observatory. The naval superintendent was retained as the administrative head. This point was criticised in the House by Mr. Reed, of Maine, and in conference the whole measure was defeated.

On September 20, 1894, the Secretary of the Navy, Mr. Herbert, established a set of "Regulations for the government of the United States Naval Observatory," to supersede the regulations which he had drawn up on April 21 of the same year. These provide for an Astronomical Director, who "shall have charge of and be responsible for the direction, scope, character, quantity, and preparation for publication of all work purely astronomical which is performed at the Naval Observatory." The regulations state that "the Superintendent of the Naval Observatory, as commanding officer, shall be charged with the general superintendence and government of the Naval Observatory." The Observatory work is divided into two classes, astronomical and nautical. The first includes the department of astronomical observations and the department of the Nautical Almanac. The second includes the department of nautical instruments, the department of chronometers and time service, and the department of magnetism and meteor-

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ology. A naval assistant is provided for the Superintendent, and provision is made for a Director of the Nautical Almanac and for heads of the various nautical departments.

On September 20, 1894, Professor William Harkness was appointed Astronomical Director. On June 30, 1897, he was also made Director of the Nautical Almanac, after the resignation of Professor Hendrickson, who occupied the position for a short time after Professor Newcomb's retirement on March 12, 1897.

The new Observatory buildings on Georgetown Heights were first occupied in 1893. The instrumental equipment is for the most part new, few of the instruments of the old Observatory having been retained in their original form. An entirely new mounting was provided for the 26-inch equatorial telescope, and the 9.6-inch telescope was replaced by a new refractor of 12 inches aperture. A large spectrograph, of modern design, was furnished for the 26-inch telescope. Two new instruments, constructed entirely of steel, were added to the equipment. One of these is a meridian circle of 6 inches aperture, and the other is a 5-inch alt-azimuth. The 8.5-inch Pistor & Martens meridian circle was furnished with a new objective of 9.1 inches aperture, and the mounting was reconstructed. All the new instruments are of American make. The work of the Observatory since its removal to the new site has included observations of the sun, moon, and planets and certain ephemeris stars (suspended from 1891 to 1894), observations of stars in the zone $-13^\circ\ 50'$ to $-18^\circ\ 10'$ of the Astronomische Gesellschaft, observations of selected stars with the prime vertical transit and the alt-azimuth, micrometric observations with the 26-inch and 12-inch telescopes. Some photographs of stellar spectra have been made with the spectrograph attached to the 26-inch telescope. The meteorological observations have been continued, but magnetic work (first seriously undertaken in 1881) has been given up, owing to disturbances caused by electric cars. Professor Yarnall's catalogue, containing the positions of all miscellaneous stars observed with the mural circle and transit instrument between 1845 and 1877 was published in 1878 (second edition). A third edition has since been brought out by Professor Frisby. Professor Eastman's catalogue of 5,151 stars, observed between 1866 and 1891, appeared in 1898. Of this catalogue the astronomical director remarks in a preface that it "has absorbed the labors of about two-thirds of the Observatory staff for more than thirty years."

A list of the naval officers who have served as Superintendent of the Naval Observatory is given in Appendix, Exhibit I.

The office of the American Ephemeris and Nautical Almanac was established by a Congressional appropriation in 1849, under the direction of Commander (later Rear-Admiral) C. H. Davis. Its headquarters were for some years in Cambridge, Mass., but were subsequently removed to Washington. Commander Davis, who later became Superintendent of the Naval Observatory, was thoroughly adapted for the duties of his position. Such men as Peirce, Runkle, Wright, Ferrel, and Winlock became members of the staff, and a high standard of excellence was at once established. The international reputation of the Nautical Almanac was greatly strengthened by the publication of the Professional Papers of the American Ephemeris and Nautical Almanac during the superintendency of Professor Newcomb, who retired in 1897.

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MINUTES OF THE PROCEEDINGS OF THE BOARD OF VISITORS.

First meeting of board of visitors to United States Naval Observatory, June 30, 1899.

The board convened at the Observatory on June 30, 1899, at 11 o'clock a. m.

Present, Messrs. Chandler, Dayton, Pickering, Hale, and Comstock. The board organized by the election of William E. Chandler as chairman and George C. Comstock as secretary.

Captain C. H. Davis, U. S. N., Superintendent of the Observatory, presented an informal statement of circumstances leading to the appointment of the board, and laid before it correspondence relative to the Observatory. (Appendix, Exhibits A and B.)

There was also submitted to the board a list of the professors of mathematics, United States Navy, with a statement of their present duties and their availability for service at the Observatory. (Appendix, Exhibit C.) The astronomical staff of the Observatory has been mainly drawn from the corps.

There was also laid before the board a list of all persons attached to the Observatory, with their respective rank. (Appendix, Exhibit D.)

At the request of Messrs. Chandler and Dayton, there was submitted to the board by its other members the correspondence conducted by them as a committee of the Second Annual Conference of Astronomers and Astrophysicists, and an abstract of letters representing the views of a considerable body of astronomers and physicists.

Mr. Pickering submitted correspondence, conducted by a committee of the American Association for the Advancement of Science, bearing upon the same subject.

After an informal discussion of the material the session was adjourned.

GEORGE C. COMSTOCK,
Secretary.

SECOND MEETING OF BOARD OF VISITORS, JUNE 30, 1899.

After examination of the Observatory and its equipment the board met at 4 p. m. Present, Messrs. Chandler, Dayton, Pickering, Hale, and Comstock.

By unanimous vote it was—

Resolved, That in view of the absence of a national university a department of science and industries, or other department or bureau especially suited to the conduct of scientific work, and in view of the diversity of opinion among astronomers regarding the proposed removal of the Naval Observatory from the Navy Department, the board believes it to be inexpedient at the present time to make any recommendations upon that subject.

Adjourned.

GEORGE C. COMSTOCK,
Secretary.

THIRD MEETING OF BOARD OF VISITORS, AT NAVAL OBSERVATORY, JULY 1, 1899.

Present, Messrs. Chandler, Dayton, Pickering, Hale, and Comstock.

Minutes of the first and second meetings were read and approved.

The chair appointed as a subcommittee upon the cost and financial condition and methods of administration of the Observatory Messrs. Dayton and Pickering.

Captain Davis appeared before the board and explained the proposed plan of organization of the Naval Observatory submitted by him to the

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Secretary of the Navy under date of September 7, 1897 (Appendix, Exhibit B), as modified by letter of March 4, 1899, and commented upon the relation of the Nautical Almanac to the Observatory.

Profs. William Harkness and S. J. Brown appeared before the board and replied to its questions relative to the same proposed plan of organization of the Observatory. Professor Brown also presented an informal account of his work at the Observatory. Pending the interview with Professor Harkness, the chairman of the board called to the chair Mr. Pickering and announced that it would be necessary for him to be absent from the remainder of the session.

Mr. Dayton announced that it would be impracticable for him to attend subsequent sessions of the board at this meeting.

FOURTH MEETING OF BOARD OF VISITORS, AT NAVAL OBSERVATORY, JULY 3, 1899

Present, Messrs. Chandler, Pickering, Hale, and Comstock.

By unanimous vote it was—

Resolved, That the board of visitors disapproves the required establishment within the Observatory of a formal astronomical council, as proposed by the Superintenent.

By unanimous vote it was further—

Resolved, That we recommend that there be established as a part of the Observatory organization a permanent board of visitors, substantially as recommended by the Superintendent.

The secretary of the present board was authorized to request from the Secretary of the Navy such documents as may be required in the preparation of a report.

Capt. C. H. Davis, Profs. A. N. Skinner, T. J. J. See, S. J. Brown, and William Harkness successively appeared before the board and presented their views relative to the organization of the Observatory.

The Superintendent was requested to inform each member of the Observatory staff that the board of visitors would receive any statement which he might desire to make relative to the Observatory.

In the absence of applications to be heard the board adjourned subject to call by its chairman.

GEORGE C. COMSTOCK,
Secretary.

FIFTH MEETING OF BOARD OF VISITORS, SEPTEMBER 26, 1899.

Pursuant to call by its chairman, the board of visitors reconvened at the Arlington Hotel, in the city of Washington, on September 26, 1899. Present, all members of the board. Minutes of the previous meetings were read and approved. Messrs. Pickering and Dayton presented their report as a subcommittee upon the financial conditions and methods of administration of the Observatory, after which the board considered in detail the drafts of a report.

Adjourned.

GEORGE C. COMSTOCK,
Secretary.

SIXTH MEETING OF BOARD OF VISITORS, SEPTEMBER 27, 1899.

The board convened at 10 a. m.—present, Messrs. Chandler, Pickering, Hale, and Comstock—and further considered the preparation of its report.

After a brief intermission and conference of the board with the Secretary of the Navy, the board reassembled at the Naval Observatory

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and received from Profs. S. J. Brown, A. N. Skinner, T. J. J. See, and Milton Updegraff written statements relative to a desired form of organization for the Naval Observatory, accompanied by oral comment thereon. (Appendix, Exhibit K.)

Prof. William Harkness and Capt. C. H. Davis also appeared before the board by request.

Adjourned.

GEORGE C. COMSTOCK,
Secretary.

SEVENTH MEETING OF THE BOARD OF VISITORS, SEPTEMBER 28, 1899.

The board convened at the Arlington Hotel—present, Messrs. Chandler, Pickering, Hale, and Comstock—and completed its report to the Secretary of the Navy.

The preceding minutes and the minutes of the meeting held September 27 having been read and approved, the board adjourned sine die.

GEORGE C. COMSTOCK,
Secretary.

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APPENDIX.

EXHIBIT A.

UNITED STATES NAVAL OBSERVATORY,
GEORGETOWN HEIGHTS,
Washington, D. C., March 4, 1899.

SIR: Referring to our recent conversation in regard to the organization of the Observatory, and in obedience to your verbal instructions, I have considered the question of appointing a board of visitors for the present year, and have reached the conclusion that it might be highly desirable to do so.

The Observatory has been the subject of much criticism on the part of outside irresponsible persons, and has been attacked in anonymous newspaper articles. There is nothing new in this. On the contrary, it has gone on ever since the Observatory has been in existence and would continue no matter what the organization might be. Much of this criticism has been directed at Professor Harkness, who under the present regulations is responsible for the direction and scope of all purely astronomical work. Professor Harkness retires in December next, and I believe that an inspection of the Observatory on the part of an intelligent and impartial board would fully vindicate his course as astronomical director, would show the institution to be efficient and in good working order for the main purposes for which it exists, and would be a sufficient answer to irresponsible criticism.

I therefore recommend that such a board be appointed. I would suggest as the proper time for the visit the close of the fiscal year, and as members I would suggest, for a board of not more than five, the chairman, or a member, of the naval committee of both House and Senate and three astronomers of recognized eminence.

I withdraw so much of a former recommendation as suggests that the members be appointed by advice of the National Academy of Sciences, and I would propose instead that they be appointed directly by the Secretary of the Navy.

I am, sir, your obedient servant,

C. H. DAVIS,
Captain, U. S. N., Superintendent of Naval Observatory.

The SECRETARY OF THE NAVY,
Navy Department, Washington, D. C.

EXHIBIT B.

PROPOSED ORGANIZATION OF THE OBSERVATORY.

DEPARTMENT OF THE NAVY,
BUREAU OF EQUIPMENT,
Washington, D. C., September 7, 1897.

SIR: Referring to your letter of 10th July respecting the organization of the Naval Observatory, we beg to submit the inclosed suggestions, which it is believed will meet fairly well the needs of the case.

The Superintendent of course should be carefully selected with reference to special fitness, and there can be no doubt that there can always be found officers in the Navy competent to administer this institution which had its beginnings and its rise to high eminence through the ability and zeal of naval officers.

Distinction in astronomy does not by any means go to show that its possessor will be a good administrator. The most eminent astronomer that France has produced was an utter failure in the administration of the national observatory at Paris, and was succeeded by an admiral of the navy under w se direction it was excellently administered.

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The system of selection of astronomers suggested, it is thought, is one to which no objection could possibly be made by the scientific world. There is no reason to suppose that these positions would not be sought after by the best men. The secure position with an assured income in age must certainly have its attractions for men of the best type. It is hardly possible that a system which has produced the two most renowned astronomers in this country may not be said to be a fairly good one.

Very respectfully,

F. E. CHADWICK,
Chief of Bureau of Equipment.
C. H. DAVIS,
Commander, U. S. N., Superintendent Naval Observatory.

The SECRETARY OF THE NAVY,
Navy Department, Washington, D. C.

The Superintendent.—A line officer of the Navy not below command rank, chosen for fitness, executive head and general administrator of the Observatory, ex officio chairman of the Observatory council.

The assistant to the Superintendent.—A line officer of the Navy, executive officer, general storekeeper, head of the department of nautical instruments, succeeds in the absence of the Superintendent.

The astronomical staff.—Four astronomers, professors of mathematics in the Navy, to retire at 68 years of age, the astronomers to be heads of astronomical departments.

Assistant astronomers.—(Number not fixed) holding rank next to astronomers on the astronomical staff, and with graded pay for length of service, to be eligible for promotion to vacancies in the corps of professors, though such promotion not to be regarded as a right. The number of assistant astronomers not to be fixed by law, but not to exceed six.

Computers.—(Number not fixed) eligible for promotion to assistant astronomers, though not of right.

The Nautical Almanac.—The chief of the Nautical Almanac to be appointed in the same manner as the astronomer, or by promotion from assistant astronomers. The organization of the office as at present. The chief the Nautical Almanac not to be a member of the astronomical council. He is responsible directly to the Superintendent as long as the office remains in the Observatory.

Division of chronometers and time service.—A line officer as head of the division. Other line officers or computers, or both, detailed as assistants as occasion may require.

Division of magnetism and meteorology.—The head of this division is preferably a line officer of the Navy. Assistants detailed as required as in the division of chronometers and time service.

In the above summary no notice is taken of subordinate staff—instrument maker, electrician, librarian, photographer, clerks, etc. The organization here would remain as at present, subject to such changes as progress might suggest.

The Observatory council.—The Superintendent and the four senior astronomers to form the Observatory council. The council shall meet monthly at least, or oftener, as summoned by the Superintendent. The senior clerk of the Observatory shall be ex officio secretary of the council. Minutes of each meeting shall be kept by him in a proper book. The majority of the council shall rule on all questions brought before it, but the Superintendent shall have the power to set aside the vote of the majority and act on his own authority and responsibility, but in doing so his action and the reasons therefor shall be entered upon the minutes of the council. The council is charged with the proper coordination of the scientific work of the Observatory under the general plan laid down by the visiting board, the executive direction being in the hands of the Superintendent. The council allots among the several scientific departments the money appropriated for astronomical and scientic expenses; chooses from its own number a library committe; details members of the astronomical staff for current work, and makes necessary changes of detail; audits expenditures for scientific work, and generally controls the whole plan and outlay for the astronomical and scientific branches of the Observatory.

The council shall not depart from the general plan laid down by the visiting board and approved by the Secretary of the Navy. Heads of departments to report weekly progress to the Superintendent, and these reports to be laid before the council.

The visiting board.—To be appointed by the Secretary of the Navy upon recommendation and nomination by the National Academy of Sciences, at the request of the Secretary. Members of the Observatory staff, including the chief of the Nautical Almanac, not to be eligible as members of the visiting board. Appointments to the visiting board not necessarily to be confined to members of the National Academy. There should be six members of the board, one-third appointed for three years, one-third for two years, and one-third for one year, until the expiration of the first

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three years, when all new appointments shall be for three years. Vacancies to be filled by appointment only for the unexpired term of the member causing the vacancy.

The board to meet once a year, at the Observatory, on a date to be fixed by the Department. At the meeting it makes an inspection of the institution, instruments, library, etc., examines the minutes of the council and the reports of heads of departments for the past year, and generally takes cognizance of the progress of work. It lays down the general course of policy to be pursued for the coming year, including printing and publication of observations, fixes the estimates for the astronomical departments, nominates to fill vacancies in the astronomical staff (either by appointment or promotion), and recommends as to repairs and acquisition of new instruments.

The board recommends the number of assistant astronomers and computers, both for the Observatory and the Nautical Almanac for the year.

The Observatory estimates should provide for the expenses of the visiting board. The board shall not exceed the powers and limits expressed in this article, and its recommendations must recognize the paramount importance of fundamental astronomical work and the needs of the naval and maritime services, and of navigation and geodesy.

The board chooses its own president and secretary.

NAVY DEPARTMENT, *Washington, June 28, 1899.*

SIR: I have the honor to inclose you herewith a memorandum making certain suggestions which the Department wishes the board, of which you are the chairman, to have in mind in making an examination of the Naval Observatory. This memorandum is not intended to finally limit the investigations of the board, but to convey certain suggestions in regard to which the Department desires to be informed, and which, it is believed, may assist the board in its work.

Very respectfully,

JOHN D. LONG,
Secretary.

Hon. WM. E. CHANDLER,
Chairman Board of Visitors, Naval Observatory, Washington, D. C.

MEMORANDUM RESPECTING THE FUNCTIONS OF THE PROPOSED BOARD OF VISITORS TO THE NAVAL OBSERVATORY.

The board of visitors is authorized to examine the equipment and working of all parts of the Naval Observatory and to make any suggestions which may seem desirable for improving the scope and efficiency thereof, but in so doing the following facts should be borne in mind:

1. Perhaps the most important astronomical duty of the Government is the publication of a nautical almanac, and as that is intended not only for the use of navigators, but also for the guidance of astronomers in the most delicate investigations known to their science, it should evidently be kept up to the highest attainable pitch of accuracy. To that end a continuous series of meridian observations upon the sun, moon, planets, and stars is absolutely necessary, and as such observations upon the sun, moon, and major planets are practically confined to the Government observatories at Greenwich, Paris, and Washington, the necessity for making them the primary work of the Naval Observatory hardly seems open to discussion. The importance of observing satellites in order to determine the masses of their primaries is evident, and in that connection the question of providing the Naval Observatory with a large heliometer may well be considered.

2. As a secondary object, the Naval Observatory has always found it possible to make many observations of asteroids, comets, and double stars, and it has recently obtained spectroscopic apparatus for investigating the motions of stars in the line of sight; but the board might well consider how far such secondary work should be extended, and whether or not it is desirable to obtain a 13-inch photographic telescope for the purpose of mapping more or less extended portions of the heavens.

3. The needs of the Navy necessitate the testing of a large quantity of instruments to be used at sea, among which chronometers occupy a very prominent position. The processes employed have gradually grown up at the Naval Observatory, and as there is very little precedent for most of them, the opinion of the board on their scope and thoroughness would be valuable.

4. The operations of the electric street railways in the vicinity of the Naval Observatory have interfered so much with the continuous magnetic observations formerly made there, as to cause their suspension. In view of the small number of

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magnetic observatories in North America, this seems so serious a loss to science that the board might well consider whether or not anything can de done to remedy it.

5. In the opinion of those responsible for the management of the Naval Observatory, its most serious defect at the present moment is the backwardness of its publications, but that has arisen through circumstances which were hardly avoidable, and which are not likely to recur in the future. The equipping of a new observatory, and the observation of the zone of stars lying between 13° 50′ and 18° 10′ of south declination for the international catalogue of the German Astronomical Society, while at the same time the series of meridian observations upon the sun, moon, and planets was continued as usual, rendered it impossible for the limited staff to keep the reductions up to date. If work is continued on the present lines, it is believed that these arrears can be brought up in about three years, and after that it should be possible to have each annual volume appear within about eighteen months after the date of the last observation it contains. As the removal to the new Naval Observatory may naturally be regarded as marking the beginning of a new series of publications, the board might well consider whether or not any changes are desirable in the forms adopted for printing the observations.

EXHIBIT C.

PROFESSORS OF MATHEMATICS, ACTIVE LIST.

William Harkness, director of Nautical Almanac.
William W. Hendrickson, Naval Academy.
Henry D. Todd, Nautical Almanac Office.
Marshal Oliver, Naval Academy.
Stimson J. Brown, Naval Observatory.
Edward K. Rawson, superintendent Library and War Records Office.
Philip R. Alger, Bureau of Ordnance.
Omenzo G. Dodge, Bureau of Yards and Docks.
Henry M. Paul, Naval Observatory.
Aaron N. Skinner, Naval Observatory.
Thomas J. J. See, Naval Observatory.
Milton Updegraff.

EXHIBIT D.

LIST OF PERSONS PERFORMING DUTY AT THE OBSERVATORY, WITH THEIR RESPECTIVE RANKS.

Capt. C. H. Davis, Superintendent.
Lieut. B. W. Hodges.
Prof. William Harkness.
Prof. S. J. Brown.
Prof. A. N. Skinner.
Prof. T. J. J. See.
George A. Hill, assistant astronomer.
Theo I. King, assistant astronomer.
F. B. Littell, assistant astronomer.
E. A. Boeger, computer.
William M. Brown, computer.
George K. Lawton, computer.
M. E. Porter, computer.
W. S. Eichelberger, computer.
F. H. Parsons.
Thomas Harrison, clerk, class 4.
R. H. Coker, clerk, class 1.
H. C. Cleve, instrument maker.
R. H. Charles, electrician.
George H. Peters, photographer.
William D. Horigan, assistant librarian.
William M. Gorman, foreman and captain of watch.
T. F. Perry, carpenter.
William Weast, engineer.
Daniel R. Nibion, fireman.
T. G. Wrenn, fireman.
William H. Malvin, fireman.
Dennis Horigan, watchman.
Nicholas Cahill, watchman.
William Henderson, watchman.
J. M. Curran, watchman.
J. C. Bronaugh, watchman.
Guy Beall, watchman.
George Anderson, skilled laborer.
G. F. Conlon, elevator conductor.

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EXHIBIT E.

CIRCULAR OF THE ASTROPHYSICAL CONFERENCE.

DEAR SIR: At the second conference of astronomers and astrophysicists, held at the Harvard College Observatory on August 20, 1898, the following resolution was adopted by unanimous vote:

"*Resolved*, That a committee of three be appointed by the conference to consider the question of the proper organization and function of the United States Naval Observatory, to draw up resolutions expressing different representative views, to obtain signatures of astronomers and astrophysicists of the country, and to present the same in person to the Secretary of the Navy by January, 1899, and to other authorities at their discretion.

"Further, that said committee be instructed to cooperate with any other committees that may be appointed in this country to consider questions connected with the scientific functions of the National Government, and to take such further action as may seem to said committee expedient."

The undersigned, elected by vote of the conference to serve as the committee designated above, request you to send to the secretary of the committee replies to the following questions, together with any suggestions you may feel inclined to offer. If for any reason a direct affirmative or negative reply can not be given to each question, it is requested that answers be made as brief as possible.

Very respectfully,

EDWARD C. PICKERING, *Chairman*,
GEORGE E. HALE, *Secretary*,
GEORGE C. COMSTOCK,
Committee.

OFFICE OF THE SECRETARY, YERKES OBSERVATORY,
Williams Bay, Wis., September 20, 1898.

(1) Can the astronomical efficiency of the United States Naval Observatory be materially increased through any change in its organization?

(2) Would the astronomical efficiency of the United States Naval Observatory be materially increased if the entire direction of the Observatory were intrusted to an astronomer?

(3) Would the astronomical efficiency of the United States Naval Observatory be materially increased by transferring the Observatory to some other Department of the Government?

(4) Would the astronomical efficiency of the United States Naval Observatory be materially increased by the separation from it of various branches of naval service now connected with it, as, for instance, the testing of nautical instruments and the care of chronometers?

(5) Would the astronomical efficiency of the United States Naval Observatory be materially increased if the regulations for its government were so amended as to make tenure of office and advancement in the staff depend upon scientific efficiency rather than upon age or length of service?

(6) Would the astronomical efficiency of the United States Naval Observatory be materially increased by the appointment of a visiting committee composed, in part at least, of astronomers of recognized professional standing?

EXHIBIT F.

LIST OF PERSONS TO WHOM CIRCULAR OF THE ASTROPHYSICAL CONFERENCE, DATED SEPTEMBER 28, 1898, WAS SENT.

C. Abbe,
C. G. Abbott,
R. G. Aitken,
J. S. Ames,
C. A. Bacon,
S. I. Bailey,
G. F. Barker,
E. E. Barnard,
C. Barus,
L. A. Bauer,
F. H. Bigelow,
L. Boss,
J. A. Brashear,
W. R. Brooks,
E. W. Brown,
S. W. Burnham,
W. W. Campbell,
H. S. Carhart,
S. C. Chandler,
F. J. Chase,
G. C. Comstock,
H. Crew,
C. R. Cross,
G. Davidson,
C. H. Davis,
H. S. Davis,
W. M. Davis,
George Dewey,
C. L. Doolittle,
A. E. Douglass,

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J. R. Eastman,
J. R. Edmands,
W. S. Eichelberger,
E. Frisby,
E. B. Frost,
W. P. Gerrish,
W. Gibbs,
J. G. Hagen,
G. E. Hale,
A. Hall,
A. Hall, Jr.;
W. Hallock,
W. Harkness,
M. W. Harrington,
C. S. Hastings,
J. F. Hayford,
J. T. Hedrick,
G. A. Hill,
G. W. Hill,
E. S. Holden,
G. W. Hough,
H. A. Howe,
W. J. Humphreys,
W. J. Hussey,
H. Jacoby,
L. E. Jewell,
J. E. Keeler,
E. S. King,
S. P. Langley,
K. Laves,
F. P. Leavenworth,
A. O. Leuschner,
H. C. Lord,
F. H. Loud,
P. Lowell,
C. Lundin,
A. T. Mahan,
F. V. McNair,
T. C. Mendenhall,
E. G. Merritt,
A. A. Michelson,
E. W. Morley,
G. W. Myers,
S. Newcomb,
E. F. Nichols,
E. L. Nichols,
H. M. Parkhurst,
J. A. Parkhurst,
H. M. Paul,
W. W. Payne,
B. O. Peirce,
C. S. Peirce,
J. M. Peirce,
C. D. Perrine,
E. C. Pickering,
W. H. Pickering,
C. L. Poor,
J. G. Porter,
E. D. Preston,
C. W. Pritchett,
H. S. Pritchett,
T. Reed,
W. M. Reed,
J. K. Rees,
C. H. Rockwell,
O. N. Rood,
A. L. Rotch,
H. A. Rowland,
J. D. Runkle,
W. C. Sabine,
T. H. Safford,
W. T. Sampson,
E. F. Sawyer,
J. M. Schaeberle,
C. A. Schott,
F. E. Seagrave,
F. H. Seares,
A. Searle,
G. M. Searle,
T. J. J. See,
A. N. Skinner,
M. B. Snyder,
W. Le Conte Stevens,
J. N. Stockwell,
O. Stone,
L. Swift,
H. O. Tittman,
D. P. Todd,
J. Trowbridge,
W. C. Tucker,
M. Updegraff,
W. Upton,
J. M. Van Vleck,
F. L. O. Wadsworth,
W. R. Warner,
A. G. Webster,
O. C. Wendell,
F. P. Whitman,
R. W. Willson,
H. C. Wilson,
A. G. Winterhalter,
R. S. Woodward,
A. W. Wright,
W. H. Wright,
C. A. Young.

EXHIBIT G.

ANSWERS TO QUESTIONS.

QUESTION 1.

Yes: Abbot, Aitken, Barker, Barus, Bigelow, Campbell, Comstock, Cross, H. S. Davis, Doolittle, Douglass, Eastman, Elkin, Flint, A. Hall, jr., Hayford, Holden, Hough, Howe, Humphreys, Hussey, Keeler, Laves, Leavenworth, Leuschner, Mendenhall, Morley, Newcomb, H. M. Parkhurst, J. A. Parkhurst, Paul, Payne, E. C. Pickering, W. H. Pickering, Reed, Rockwell, Rotch, Runkle, Safford, Sawyer, Seares, Stevens, Stone, Swift, Upton, Wilson, Young.

No: Abbe, Jacoby.

REMARKS.—Abbe: Not so long as it is considered as a naval store station. Barker: In my judgment, there is no doubt that it can. Barnard: I am not sufficiently familiar with the present management of the Observatory, but I believe it would be. Bigelow: It should have a director and assistants, in fact, subordinate to him. Comstock: As suggested under questions 2, 5, and 6. Crew: Have no opinion. H. S. Davis: Very materially indeed. Doolittle: I think it can; I would place a capable man in charge, give him full authority, and hold him responsible for the results; in my own opinion, the best attainable results can not be had under any system of management or organization so long as the Observatory remains in Washington; the atmosphere is too highly charged with politics. Flint: It seems to me that the main point to dwell upon is the accomplished fact of a large and expensive observatory, equipped for astronomical research far beyond the possible needs of any Government service. Frost: Probably. Hale: I think it can. Hayford: A naval observatory should be made, both in name and fact, a national observatory; it will be a naval observatory so long as any position or positions connected with it are filled by naval officers permanently, and so long as control over its personnel or policy lies to any degree in the hands of a naval officer; it will become a national observatory when the policy and financial management are lodged entirely in the hands of men who are under no obligations to the United States Navy, United States Army, or any other

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organization existing for other than astronomical purposes, and who are known to be able astronomers; I do not consider the Secretary of the Navy to be a naval officer, and it seems to me that a national observatory would be as safe in his hands as in that of any other Cabinet officer—and it must be in the hands of some Cabinet officer—provided the law in regard to the Observatory is changed as indicated above. Hough: Vide 2, 5, and 6. Hussey: Place it under the direction of a competent, practical astronomer. Myers: I think so. E. F. Nichols: I think it can. Newcomb: Very greatly. H. M. Parkhurst: An astronomical observatory would be more efficient astronomically than a naval observatory. Paul: Certainly; no question about it. Payne: As shown by other great observatories in the United States and Europe. Perrine: I think it can. Porter: I can not say. Searle: Probably; but none of the suggestions in questions 2 to 6 seem to me to have any direct tendency to improve matters. Skinner: The Naval Observatory has never been organized; what it needs is, in the first place, a complete organization. Snyder: The present organization is both grossly absurd and astronomically inefficient; the history of the Observatory has shown that nonastronomical naval officers are failures as superintendents. Todd: Perhaps so, but not certainly. Updegraff: I believe that it can. Upton: By removing it from control of line officers of Navy and making it a scientific institution under control of some Department, like the United States Coast and Geodetic Survey, under Treasury Department, or United States Weather Bureau, under Agricultural Department. Wadsworth: See reply to 2. Warner: Whether a change would be an improvement or not would depend on the personnel of those in charge. Wilson: By some change that would place its control wholly in the hands of recognized astronomers. Woodward: The astronomical efficiency can be materially increased by appointing astronomers only, for reasons of merit only, to positions in the service. Young: Certainly.

QUESTION 2.

Yes: Abbot, Aitken, Barker, Barnard, Barus, Campbell, Comstock, Cross, Douglass, Eastman, Elkin, Flint, Frost, Gerrish, A. Hall, jr., Hayford, Holden, Hough, Howe, Humphreys, Hussey, Keeler, King, Laves, Leavenworth, Leuschner, Mendenhall, Newcomb, E. F. Nichols, H. M. Parkhurst, J. A. Parkhurst, Paul, Payne, Perrine, E. C. Pickering, W. H. Pickering, Porter, Reed, Rockwell, Rotch, Runkle, Safford, Sawyer, Schott, Seares, Skinner, Snyder, Stevens, Stone, Swift, Upton, Wilson, Young.

No: Abbe, Bigelow, Jacoby.

REMARKS.—Abbe: Not if that be the only change. Abbot: If Observatory were transferred, as in 3, and the director freed so far as possible from nonastronomical executive business. Barker: I believe that it would. Barnard: Certainly, because he would be more familiar with what an observatory should do. Barus: If the choice is made by a board of experts, preferably by the National Academy. Bigelow: It must be in a Department to secure annual appropriations. Comstock: Provided the astronomer was chosen with due regard to executive ability. Crew: This would depend upon the tastes and ability of the astronomer; no general answer possible. Cross: If care is taken that he is a man of large executive ability as well. H. S. Davis: Individual responsibility and the guidance of an astronomer are certainly the fundamental requisites for efficiency in any astronomical observatory. Doolittle: Probably it would, though that would depend entirely on the man himself. Gerrish: If sufficient care were exercised in securing an able executive officer as well as astronomer. Hale: I think it would if the astronomer were skilled in his profession, broad and liberal in his views, and possessed of executive ability. Hussey: But the astronomer must be the proper man for the place; all would depend upon that. Keeler: All successful observatories are so directed. Leavenworth: Undoubtedly, if the right astronomer is obtained. Morley: Probably it would. Myers: I think so. Newcomb: If the astronomer were carefully selected as he ought to be. E. F. Nichols: I think it certainly would. H. M. Parkhurst: But probably subject to the supervision of the visiting committee spoken of in question 6. Paul: Certainly, and he should be the ablest astronomer to be had in the country. Payne: That is the experience of the last fifty years. Porter: I should think so. Rotch: Provided he was a good administrator. Skinner: The Naval Observatory should have one head; that head should be an astronomer. Snyder: Certainly, the "entire direction" to an astronomer who has an adequate conception of what the Observatory should be as a great Government institution. Todd: Probably; would depend on who the astronomer is. Updegraff: I believe that it would. Wadsworth: Director should be either an astronomer or one strongly in sympathy with astronomical work and scientific ideals. Warner: Not necessarily; the director should also possess great executive and organizing ability. Wilson: If the astronomer were selected for his recognized executive ability, and not because of some notable astronomical discovery. Woodward: It would, provided such astronomer could work in cooperation with his subordinates and give them a chance to advance in accordance with merit, along with himself. Young: Certainly.

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QUESTION 3.

Yes: Abbot, Barnard, Cross, Eastman, Flint, Holden, Howe, Humphreys, Keeler, Leuschner, Mendenhall, Morley, J. A. Parkhurst, Paul, W. H. Pickering, Rockwell, Stone, Swift, Young.

No: Abbe, Bigelow, Campbell, Gerrish, Hayford, Hussey, Jacoby, Myers, Perrine, Rotch, Runkle, Safford, Sawyer.

REMARKS.—Abbe: Not if that be all that is done. Abbot: To the Smithsonian Institution. Aitken: I do not know. Barker: Not necessarily, I think, unless a department of scientific institutions was created. Barnard: I believe it would do much better under any Department than the Navy. Barus: Not necessarily, provided the choice of director is made as per 2. Bigelow: The same difficulties would occur in some other form. Comstock: I have not come to a definite opinion upon this matter. Crew: Have no opinion. Cross: I believe that there should be a department in charge of all scientific work. H. S. Davis: Logically and historically, the Navy Department is the proper one. If any change is practicable, the separation of the Observatory entirely from all the present Departments might be a fruitful source of reform. Doolittle: If it were placed under the Department of Agriculture it would probably receive more attention, which might or might not be desirable. Douglass: That would depend upon its management. The Naval Observatory should have, first, an astronomer as director, with full control of the institution; second, the power to appoint the director should be in the hands of a visiting committee, of which a majority are astronomers and of which the chairman would be some suitable Government official, or else some other plan should be adopted by which there would be no possibility of political control of the Observatory. Elkin: On this point I can not give a definite opinion. Frost: Doubtful. Hale: Possibly, but under existing circumstances I doubt the expediency of attempting to secure such a transfer. A. Hall, jr.: Probably. Hayford: Not unless said department were a new one, to have charge of the scientific work of the Government and nothing else. Hough: Probably not. Howe: Except to War Department. Humphreys: If to the proper department. Keeler: Probably; in the absence of a distinct scientific bureau a national observatory might be placed, like the Geodetic Survey, under the Treasury Department. King: Question. Laves: I do not know. Leavenworth: Probably, if an astronomer were given direction as in 2. Leuschner: A general scientific department should be created. Morley: Very probably it might be. Myers: I do not think so. Newcomb: It would if it can not be properly organized under the Navy Department. E. F. Nichols: It seems to me that the scientific work of the Observatory would be less hampered if some such transfer could be made. H. M. Parkhurst: Astronomical work has no relation to Government. J. A. Parkhurst: The scientific work of the United States might with advantage be concentrated in a "department of science." Paul: Certainly; the whole military spirit and sentiment of the Navy is utterly out of keeping with the true spirit and methods of scientific research. Payne: It probably would be, because the influence of officers from the Navy side has been a positive damage to astronomical work and progress generally. E. C. Pickering: Doubtful. W. H. Pickering: Perhaps. Porter: Can not say. Reed: Such transfer might be advisable, but scarcely seems necessary. Rotch: Unless a department embracing all the scientific bureaus was created. Schott: So long as it is a "Naval" Observatory it properly belongs to the Navy Department. Seares: I am doubtful as to this. Skinner: I am not sure that a transfer would improve matters; a unification in organization and object is the desideratum. Snyder: If such transference led to the main point—direction absolute by an astronomer; otherwise not. Stevens: I can not answer this question. Todd: I think not, unless to a department of science, should such be created, as recently proposed. Updegraff: I am unable to give an opinion based on my own knowledge. Upton: Not necessarily. It might remain under Navy Department if change suggested under 1 were made. Wadsworth: I do not think so. Temporarily, such a transfer now would probably be detrimental. Warner: If the Observatory, together with all other scientific departments of the Government, could be organized as a "department of science" I think great good would result. Wilson: Probably the Department of the Interior would be free from some of the objections to the present control. Woodward: Probably, because the Observatory would thus be set free from hampering traditions; it would not then be possible to create ex officio or "shore-duty" astronomers. Young: I think it would be better under the Interior Department, unless we can have a department of education and science.

QUESTION 4.

Yes: Aitken, Barker, Douglass, Eastman, Flint, A. Hall, jr., Holden, Howe, Humphreys, Laves, Leuschner, Mendenhall, Morley, Myers, E. F. Nichols, Paul, E. C. Pickering, W. H. Pickering, Porter, Runkle, Seares, Stevens, Swift, Updegraff, Young.

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No: Abbe, Abbot, Barus, Bigelow, Campbell, Comstock, Frost, Gerrish, Hayford, Hussey, Jacoby, Leavenworth, Perrine, Safford, Sawyer, Todd, Upton, Wadsworth, Warner.

REMARKS.—Abbe: These do not impede its work. Barker: It would in my opinion, assigning these to the Bureau of Navigation, perhaps. Barnard: If this work is to be done by the regular astronomers themselves it should be discontinued. Barus: Not if specified appropriations are made for each branch of the service. Bigelow: The only hope of Congressional aid is to have simple and useful things to do. Campbell: Not appreciably; the "time service" must be kept up in any case, and one or two detailed officers could do the rest. Comstock: So long as the Observatory remains in the Navy Department. Crew: Slightly. H. S. Davis: Not necessarily; this depends on the size of the appropriations and the force of assistants thereby available. Doolittle: This seems to be merely a matter of practical convenience. Probably the Navy would in any case have charge of chronometers, etc. If the Observatory were transferred, a separation would naturally follow. Douglass: Such work would have to be under the control of the Navy in any case. Eastman: If sent to some Department, like the Interior, where the strict bureau system does not prevail, and where immediate access to the Secretary is practicable. Elkin: On this I can hardly give a definite opinion. Flint: Especially by making its independence more nearly complete. Frost: Probably not. Gerrish: This is valuable work, and is one of the few branches which appeal to public interest. Hale: The care of these instruments need not seriously interfere with the scientific work of the Observatory. A. Hall, jr.: I think so, for it would be better for the line officers of the Navy to do this work. Hough: Probably not. A Government observatory might well conduct magnetical and meteorological observations, etc., without impairing strictly astronomical work. Humphreys: Or else by making such work subsidiary to the work of the Observatory. Hussey: Under competent direction they need not materially affect its astronomical efficiency. Keeler: Not necessarily; some plan of cooperation with the Navy Department could be arranged to avoid duplication of work. Leavenworth: I know of no reason why it should. Myers: Most certainly it would. Newcomb: Not unless the money thus saved was expended for astronomical work. E. F. Nichols: I believe it would. H. M. Parkhurst: That should be decided by the director or the supervisory committee. J. A. Parkhurst: It would if these branches interfere with the astronomical work. Paul: Certainly; all of it could be better and more economically done for the Atlantic coast at the New York Navy-Yard, just as it has been done for years for the Pacific coast at the Mare Island yard. Payne: Not necessarily, if the care of instruments was in the hands of the instrument maker of the Observatory, and the care of chronometers was in the hands of a competent assistant astronomer. Perrine: I do not consider that such branches need be any hindrance, and they certainly belong to this Department. E. C. Pickering: If Observatory is transferred to another Department. W. H. Pickering: Perhaps. Reed: By making these branches distinct from the astronomical work, certainly; their entire separation probably unnecessary. Rockwell: Immaterial. Rotch: Yes, with the same appropriation of men and money. Schott: Not much. Skinner: It possibly might, if this should contribute to a unification of the purpose and activity of the Observatory. Snyder: No use in separating from it any work it Observatory is properly directed. Instruments could even be properly tested by navy men under good direction. Stevens: Such testing might be done under its direction in a general way, if necessary. Stone: The Observatory should be entirely separated from naval control. Todd: All these should be retained. Updegraff: I believe that it would. Upton: These duties may well be retained as a minor part of its work, with naval officers attached to it for this purpose, should this seem best. Wadsworth: Not necessarily. Warner: Give it more to do, rather than less. Wilson: I don't think this would make any great difference. Woodward: Not materially, provided the Observatory could act independently of the Navy.

QUESTION 5.

Yes: Aitkin, Barker, Barnard, Barus, Bigelow, Campbell, Comstock, Crew, Cross, Doolittle, Douglass, Eastman, Elkin, Flint, Hale, A. Hall, jr., Hayford, Hough, Howe, Humphreys, Keeler, King, Laves, Leavenworth, Leuschner, Mendenhall, Morley, Myers, Newcomb, E. F. Nichols, H. M. Parkhurst, J. A. Parkhurst, Paul, Payne, Perrine, E. C. Pickering, W. H. Pickering, Porter, Reed, Rockwell, Rotch, Runkle, Safford, Sawyer, Schott, Seares, Snyder, Stevens, Swift, Todd, Updegraff, Upton, Warner, Woodward.

No: Gerrish, Jacoby.

REMARKS.—Abbe: To a small extent, provided you can secure a high standard for testing "scientific efficiency." Barker: Unquestionably, as I view it. Barnard: This would certainly be an incentive to good work and more of it. Bigelow: This is the best reform to carry out. Comstock: Emphatically. H. S. Davis: Ideally, yes;

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practically, it is doubtful. There is much room for abuse of any "regulation" established without a fixed standard of efficiency and where the criterion of judgment may therefore be prejudice. Doolittle: Provided it could be kept free from political methods. Flint: With a humane consideration for the latter. Frost: Probably, so far as compatible with the reform civil service. Gerrish: This would be likely to miscarry and bring about the exercise of favoritism. Hale: If provision could be made for carrying such amended regulations into effect. Holden: It would depend on who was the official judge of "scientific efficiency." Humphreys: Emphatically. Hussey: The scientific efficiency of an observatory depends upon the morale of the staff. This is largely determined by the character and attainments of the director and the manner in which he exercises authority, and also by the rewards that await those who render distinguished services. Leavenworth: I think so. Morley: The Coast and Geodetic Survey is much more efficient than the Naval Observatory. Myers: Obviously. E. F. Nichols: I certainly believe it would. J. A. Parkhurst: Most assuredly. Paul: Certainly; the former is the only correct policy. Payne: I think so, because merit is a better principle for advancement than the other. The civil service illustrates it. Perrine: Although length of service, etc., should be taken into account. Porter: Certainly. Reed: With appointment from outside instead of advancement when efficiency demands it. Runkle: Without doubt. Skinner: In general I should say yes. This condition of tenure of office exists to some extent at present. Snyder: Advancement should depend upon efficiency alone; but certainty of tenure conduces to general efficiency even if increase in age decreases personal efficiency. Stone: Tenure of office should of course depend primarily on scientific efficiency, but not so as to exclude consideration of length of service. Whether a change in the regulations would bring this about can not be stated positively. Probably an improvement could thus be effected. Wadsworth: Under ideal conditions, yes; under actual conditions existing in Government service it would be a dangerous experiment. Warner: I believe such a change would be a great benefit. Wilson: Probably it would, but continuity of management, with proper stimulus to exertion, is essential. Woodward: Undoubtedly. The professional service of the Observatory has been disgracefully debauched in the past by the appointment of notoriously unfit men. Merit has had little chance in competition with nepotism, politics, and pulls. Young: I think both should be taken into account. Mere seniority promotion is bad; favoritism is worse.

QUESTION 6.

Yes: Abbot, Barker, Barus, Campbell, Comstock, Cross, Flint, Frost, Gerrish, Hale, A. Hall, jr., Holden, Hough, Howe, Humphreys, Jacoby, Keeler, King, Laves, Leavenworth, Mendenhall, Myers, E. F. Nichols, H. M. Parkhurst, J. A. Parkhurst, Payne, Perrine, E. C. Pickering, W. H. Pickering, Porter, Rockwell, Rotch, Runkle, Safford, Sawyer, Seares, Skinner, Stevens, Stone, Todd, Updegraff, Wadsworth, Warner, Wilson, Woodward, Young.

No: Abbe, Aitken, Barnard, Bigelow, Hayford, Hussey, Leuschner, Snyder.

REMARKS.—Abbe: Not so long as the committee is merely advisory and ornamental. Aitken: I doubt it. Barker: I think it would. Certainly astronomical work would then be done, and that of a higher grade. Barnard: I do not feel sure that this would be a wise plan. I am not in favor of it. Barus: This visitation should be made by the National Academy as the legal scientific representatives of the Government. Bigelow: A more complicated form than the present one is not needed. Campbell: Provided the committee is given considerable power (see additional communication). Crew: Slightly. H. S. Davis: Presumably yes, provided other forms are adopted; but if the Observatory's present organization remain unchanged such a committee could effect nothing. Doolittle: If they were given authority to correct abuses, yes; otherwise, no. Douglass: It would if that committee had authority to act (see answer to 3). Eastman: I don't think it would under the present organization. Under any organization a visiting committee is liable to do more harm than good. Such a committee might, under proper conditions, be of great service, but they would need to be models of wisdom, tact, and patience. Elkin: I doubt if a visiting committee, without controlling power, would exercise much influence. Hale: It probably would if the committee were properly organized. Hayford: Not unless such visiting committee is given something more than the power of giving advice—which is very unlikely. Hough: It would be in line with some other Government observatories. Humphreys: In all probability. Hussey: The Naval Observatory has already a superabundance of "red tape." Leuschner: I am not in favor of a visiting committee, but the director should make an annual statement before a national conference of astronomers and astrophysicists, and should be guided by its suggestions in mapping out the work of the national observatory. Mendenhall: If composed entirely of astronomers or men learned in related sciences. Morley: The National Academy of Science might be of service as a board of visitors or by appointing such a board. Myers: It could not be otherwise affected, I think.

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Newcomb: Not unless the scientific members of the committee were in control. H. M. Parkhurst: Especially if they had supervisory power. Paul: Not under the present management; but, with a proper astronomer as director, and entirely free from military supervision, such a committee would doubtless be welcome and of great assistance to the director. Payne: I think so. This is a well-established principle, everywhere in use under similar circumstances. Reed: Probably. Rockwell: Provided they have authority to enforce their recommendations. Safford: I regard the action proposed in 6 as highly important, as you, as a committee, will readily infer from many passages in Sir George Airy's autobiography, which will also furnish good reasons for my answers to the other questions. Snyder: No more than by the visit of a committee of inquisitive women. Select an efficient astronomer, and give him the entire responsibility and the entire power of direction, and then only may respectable results be attained. Swift: Perhaps. Todd: Also the director or superintendent should be a member of the visiting committee, and their recommendations should be obligatory. Updegraff: I believe that it would. Upton: Not necessarily. Wadsworth: Provided such a committee were carefully and properly chosen. Warner: Such committees visiting the military and the naval academies and the mints do excellent service. Wilson: Undoubtedly it would. Woodward: I think it would. A board of regents similar to that of the Smithsonian Institution could do much to improve the status of the Observatory. Young: I think it would. I regard this as the most important of all the suggestions implied by the questions.

EXHIBIT H.

FINANCIAL CONDITION OF THE OBSERVATORY.

UNITED STATES NAVAL OBSERVATORY,
Washington, D. C., August 7, 1899.

DEAR SIR: I inclose two memoranda, which will, I think, give the information sought by your letter of July 7.

Very truly, yours,
C. H. DAVIS,
Captain, U. S. N., Superintendent of Naval Observatory.

Prof. EDWARD C. PICKERING,
Harvard College Observatory, Cambridge, Mass.

United States Naval Observatory—Cost of grounds and buildings.

Grounds, and the improvement thereof	$66,053.78
Office building (main building)	287,000.00
Great equatorial building, with elevating platform, additions, double floor (under movable floor)	51,000.00
Clock and observers' rooms, two transit-circle buildings, and prime-vertical building	55,000.00
Magnetic observatory	3,700.00
Boiler house, dynamo house, pump house, standpipe, with boilers, engines, and dynamos	39,000.00
Dwelling houses ($20,000, one; $12,500, two)	32,500.00
Other buildings	5,000.00
Total for buildings	473,200.00

Appropriations for United States Naval Observatory, legislative act approved March 15, 1898, for year ending June 30, 1899.

For salaries	$37,460.00
Expended	36,130.00
Balance unexpended	1,330.00

This large unexpended balance was due to the prolonged sickness, without pay, of an employee, and to vacancies existing for some months, etc.

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For miscellaneous computations	$1,200.00
Expended	1,200.00
For professional and scientific books, etc	500.00
Expended	475.34
	24.66
Requisition not yet fulfilled	24.66
For apparatus and instruments, etc	2,000.00
Expended	1,002.18
	997.82
Outstanding contracts and requisitions in process of fulfillment	997.00
Balance unexpended	.82
For repairs to buildings, etc	2,500.00
Expended	1,508.01
	991.99
Requisitions not yet fulfilled and obligations	889.24
Balance unexpended	2.75
Fuel, oil, pipe, etc	7,500.00
Expended	6,618.15
	881.85
Requisitions outstanding and obligations	876.32
Balance unexpended	5.53

Naval Observatory—For grounds and roads—Naval appropriation act, approved May 4, 1898; year ending June 30, 1899.

For continuing grading, extending roads and paths, clearing and improving grounds	$5,000.00
Expended	4,999.71
Balance unexpended	.29
Building a conduit for underground service for wires, pipes, etc	5,000.00
Expended	4,999.97
Balance unexpended	.03
Building a double floor (under the movable floor), 26-inch equatorial dome, double doors at entrance to basement, and alterations to machinery	1,200.00
Contract (not yet fulfilled) $917.34	
Requisitions for materials (not yet fulfilled) 282.66	
	1,200.00

Grounds and permanent improvements.

Original cost of site, with incidental expenses	$64,696.88
Standpipe, well, steam pump and house, water, steam, heating, lighting, and fire-plant connections and conduits	42,644.25
Expended in inclosing, grading, clearing, and improving grounds, making and extending roads and paths	74,159.53
Additions to permanent improvements from legislative bills, 1894–1899	1,670.91
Total for grounds and permanent improvements	183,571.57

Buildings.

Main building, original cost, including changes and modifications to date	$283,164.09
Boiler and dynamo buildings	24,840.03
Great equatorial building	51,595.78
East, west, and south transit buildings	36,670.72

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Prime-vertical transit building	$5,402.82
Clock building and piers and observers' rooms	14,358.36
Magnetic observatory and photographic house	3,832.01
Official residence of superintendent	19,999.54
Dwellings for two observers	12,500.00
Barns, stables, hothouses, and other outbuildings	5,149.48
Total	457,512.83

Instruments and accessories.

1. Great equatorial and accessories (including elevating floor)	$58,695.00
2. East meridian circle (Pistor & Martins, 9-inch, remodeled)	10,326.95
3. South transit instrument	1,599.00
4. Prime-vertical instrument	3,032.20
5. 12-inch equatorial	6,125.00
6. 6-inch transit circle (Warner & Swasey)	10,463.50
7. 5-inch alt-azimuth and building (Warner & Swasey)	7,080.00
8. 1 comet seeker, 4-inch (Brashear), alt-azimuth	400.00
9. 1 comet seeker, 4-inch (old equatorial mounting)	280.00
10. 13 astronomical clocks	4,830.00
11. 7 chronographs (with stands and scales)	3,701.00
12. 3 personal-equation apparatuses	230.00
13. 2 level triers	99.00
14. Meteorological apparatus	791.75
15. Transit of Venus measuring engine	1,500.00
16. Equipment of magnetic observatory	5,957.55
17. 1 kathetometer	400.00
18. Instruments for testing sextants	1,500.00
	117,010.95
Instruments unmounted:	
9.6-inch equatorial, 7¾ equatorial, and Repsold transit circle (Naval Academy), transit of Venus outfits, etc	36,452.00
Total	153,462.95
Furniture in all buildings (estimated)	8,000.00
Horses, carriages, carts, wagons, harness, etc. (estimated)	2,500.00
Lathes and other tools	1,500.00
Total	12,000.00

RECAPITULATION.

Grounds and permanent improvements	$183,571.57
Buildings	457,512.83
Instruments in use	117,010.95
Instruments not in use	36,452.00
Furniture, tools, horses, carriages, etc	12,000.00
Library (estimated)	50,000.00
Total	856,547.35

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EXHIBIT I.

SUPERINTENDENTS UNITED STATES NAVAL OBSERVATORY, WITH THE PERIOD OF EACH ADMINISTRATION FROM OCTOBER 1, 1844.

Superintendents.	From—	To—
Matthew F. Maury	Oct. 1, 1844	Apr. 20, 1861. (Resigned.)
James M. Gilliss	Apr. 23, 1861	Feb. 9, 1865. (Died.)
William B. Whiting (ad interim)	Feb. 9, 1865	Apr. 28, 1865. (Relieved.)
Charles H. Davis	Apr. 28, 1865	May 15, 1867. (Detached.)
Benjamin F. Sands	May 15, 1867	Feb. 23, 1874. (Detached.)
Charles H. Davis	Feb. 23, 1874	Feb. 18, 1877. (Died.)
Charles H. Davis II (ad interim)	Feb. 18, 1877	May 1, 1877. (Relieved.)
John Rodgers	May 1, 1877	May 5, 1882. (Died.)
William T. Sampson (ad interim)	May 5, 1882	July 1, 1882. (Relieved.)
Stephen C. Rowan	July 1, 1882	May 2, 1883. (Detached.)
Robert W. Shufeldt	May 2, 1883	Feb. 21, 1884. (Detached.)
Samuel R. Franklin	Feb. 21, 1884	Mar. 31, 1885. (Detached.)
Allan D. Brown (ad interim)	Mar. 31, 1885	June 1, 1885. (Relieved.)
George Belknap	June 1, 1885	June 7, 1886. (Detached.)
Allan D. Brown (ad interim)	June 7, 1886	Nov. 15, 1886. (Relieved.)
Robert L. Phythian	Nov. 15, 1886	June 28, 1890. (Detached.)
Frederick V. McNair	June 28, 1890	Nov. 21, 1894. (Detached.)
Robert L. Phythian	Nov. 21, 1894	July 19, 1897. (Detached.)
Charles H. Davis II	July 19, 1897	Apr. 16, 1898. (Detached.)
Walton Goodwin (ad interim)	Apr. 16, 1898	May 18, 1898. (Detached.)
Robert L. Phythian	May 18, 1898	Nov. 1, 1898. (Detached.)
Charles H. Davis II	Nov. 1, 1898	

EXHIBIT J.

MEMORANDUM RESPECTING THE PUBLICATIONS OF THE UNITED STATES NAVAL OBSERVATORY.

The volume for 1890 was issued in 1895. The contents of the subsequent volumes should be as follows:

VOLUME FOR 1891.

Astronomical observations with the 8.5-inch transit circle, January 2 to June 29 (dismounted in July); 26-inch equatorial telescope, January 3 to December 30; 9.6-inch equatorial telescope, January 5 to December 31.

The magnetic observations for this year have been printed as Appendix II to the volume for 1888.

Meteorological Observations and Results.

Appendix I, Part I of the observations of the transit of Venus, December, 1874.

VOLUME FOR 1892.

Astronomical observations with the 26-inch equatorial telescope, January 6 to December 13 (dismounted in December); 9.6-inch equatorial telescope, March 11 to September 30 (dismounted in October).

The magnetic observations for this year have been printed as Appendix 1 to the volume for 1889.

Meteorological Observations and Results.

Appendix I, Second Washington Catalogue of Stars. (Separate copies issued in 1898.)

VOLUME FOR 1893.

Description of the new Naval Observatory.

Astronomical observations with the prime vertical transit instrument, July 27 to December 31; 9.6-inch equatorial telescope, July 12 to December 13.

During this year the magnetic observatory was being moved from the old to the new site, and no magnetic observations were made.

Meteorological Observations and Results.

VOLUME FOR 1894.

Astronomical observations with the 9.1-inch transit circle; first half of the Astronomische Gesellschaft zone; from October 10 to December 31, sun, moon, and planets. Prime vertical transit instrument throughout the year.

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Meridian instrument, Stackpole & Bro., No. 1502, after November 22. 26-inch equatorial telescope throughout the year. 9.6-inch equatorial telescope throughout the year.

Meteorological Observations and Results.

Appendix I, Magnetic Observations and Results. (Care should be taken to see that they are bound up in their proper place at the end of the volume. The separate copies were published in 1895.)

VOLUME FOR 1895.

Astronomical observations with the 9.1-inch transit circle; second half of the Astronomische Gesellschaft zones; sun, moon, and planets throughout the year. Prime vertical transit instrument throughout the year. Meridian instrument Stackpole & Bro., No. 1502, throughout the year. 26-inch equatorial telescope throughout the year. 9.6-inch equatorial telescope, with 9.6-inch object glass to December 19; after that with 12-inch object glass.

Magnetic Observations and Results.

Meteorological Observations and Results.

The volumes for 1896, 1897, 1898, and 1899 will be similar to that for 1895, except that they will contain no magnetic observations, and after February, 1898, the meridian instrument Stackpole & Bro. No. 1502 was replaced by the 5-inch alt-azimuth instrument.

The manuscript of the volumes for 1891 and 1892 will probably be in the hands of the printer within a week, but there will necessarily be considerable delay in preparing the subsequent volumes. The manuscript of the volumes for 1893 is complete so far as the astronomical and meteorological observations are concerned, but nothing has been done toward preparing the description of the new Naval Observatory, and that, with the accompanying illustrations, will involve a large amount of labor. The volumes for 1894 and 1895 will contain the observations for the German Astronomical Society's zone, lying between 13° 50′ and 18° 10′ of south declination, and their reduction can scarcely be completed before the middle of 1900. After that the volumes for 1896 and subsequent years can be prepared with great rapidity. I estimate that the printing of all of them can be brought up to date in from three to four years.

In my opinion, the work of the Naval Observatory can easily be so arranged that in the future the observations of each calendar year shall be completely reduced by the beginning of the next following July, and then, if a full year is allowed for the printing of each volume, the volumes should be issued within eighteen months of the date of the last observations they contain.

WM. HARKNESS,
Professor of Mathematics, United States Navy, Astronomical Director.

EXHIBIT K.

UNITED STATES NAVAL OBSERVATORY,
GEORGETOWN HEIGHTS,
Washington, D. C., September 26, 1899.

SIR: In response to an invitation extended through the Superintendent, I take pleasure in briefly stating my opinion on certain salient points which seem to me to be essential to insure the successful administration of the Naval Observatory:

First. All the astronomical work should be under the charge of an astronomical director, who shall be the senior professor on duty at the Observatory.

Second. The astronomical director and the other professors on duty at the Observatory shall constitute a council, which shall meet at certain stated intervals. The astronomical director shall be governed in his administration by a majority vote of the council.

Third. All publication of astronomical work shall be under the charge of the astronomical director.

Fourth. It should be made a matter of legal enactment that the Observatory should be visited annually by a board of visitors consisting of three representative astronomers, a Senator, and a Member of Congress. The functions of the board of visitors should be purely advisory.

Very respectfully,

AARON N. SKINNER,
Professor of Mathematics, United States Navy.

Hon. WILLIAM E. CHANDLER,
Chairman Board of Visitors.

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UNITED STATES NAVAL OBSERVATORY,
Washington, D. C., September 26, 1899.

SIR: As the board of visitors at its former sitting, when two of the members were absent, solicited my views on the future of the Observatory, it seems not inappropriate to submit for the final deliberations of the board a memorandum of what was then said:

(1) That it is difficult to see how the continuity and uniformity of any general plan of work undertaken by the Observatory can be guaranteed except by the continuation of the astronomical directorship, which should be held by the senior professor of mathematics.

(2) In order that the astronomical director may have the benefit of advice and cooperation in the execution of the astronomical work, it is advisable that an Observatory council, to be composed of all the professors of mathematics on duty, should be established; that any change in the scientific work of the Observatory should require the approval of this council before it can be definitely entered upon.

(3) That the board of visitors should be made permanent, in order that the Observatory may always be assured of a wider range of counsel and advice.

(4) That in the reassignment of work, which will follow the retirement of Professor Harkness, especial care should be exercised to ascertain the aptitude and interests of the several observers, in order that their work may be that which by interest, training, and experience they can do best.

(5) That in perfecting the instruments, the astronomical director should scrupulously consult the wishes of the observers who are to use them, in order that the observers alone may be reponsible for any failure to accomplish efficient service.

(6) That the several lines of work to be undertaken by the Observatory should be carefully considered by the council, in order that when they are definitely entered upon they may be adhered to on a uniform plan until completed.

(7) As prompt publications of observations is recognized to be almost as desirable as the execution of the work itself, a safe policy would be to have all observations published within one fiscal year of their completion, and the scope of work undertaken should be so restricted that it can be managed upon this basis.

(8) Any change in our established policy, looking to economy by the introduction of cheap labor into our computing force, would necessarily lower the standard of the scientfic work, which has hitherto been of high grade, and result disastrously to the public interests.

Respectfully submitted.

T. J. J. SEE,
Professor of Mathematics, United States Navy.

Hon. WILLIAM E. CHANDLER,
Chairman Board of Visitors, United States Naval Observatory.

UNITED STATES NAVAL OBSERVATORY,
BUREAU OF EQUIPMENT, NAVY DEPARTMENT,
Washington, D. C., September 25, 1899.

DEAR SIR: I desire to submit for the consideration of the board of visitors the following statement of my views concerning the management of the astronomical work of the Naval Observatory. I have been on active duty in the Observatory for two months, and this statement is based on my experience here during that time and on fifteen years' experience elsewhere as an astronomer.

The astronomical directorship should, in my opinion, be maintained for obvious reasons, the senior astronomer in the corps of professors of mathematics to hold the position. I am inclined to think that the routine executive work of the astronomical director might be so arranged that he could do some astronomical work also.

I believe that a standing board should be constituted, consisting of the professors of mathematics on duty at the Observatory, and that to this board should be referred for final decision all important questions pertaining to—

(*a*) Astronomical work to be undertaken.
(*b*) Methods used in astronomical work.
(*c*) Changes in instrumental equipment.
(*d*) Assignment of men to duty.
(*e*) Publication of results.

The astronomical director should, I think, be chairman of the board and have one vote.

The establishment of this board is, in my opinion, necessary, in order that the entire professional experience of the astronomers of the Observatory may be utilized, as far as possible, in the management of the astronomic work.

In assigning a man to take charge of an instrument, the chief consideration should be his fitness for the work in a broad sense. While on the one hand he should be

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given as much freedom as possible in choice of methods, he should on the other hand be held alone responsible for the amount and character of the results produced. The zeal and capacity of the man behind the telescope is the most important factor in the execution of astronomical work, and in any successful system of management of an Observatory this fact must, in my opinion, be recognized.

Respectfully submitted.

MILTON UPDEGRAFF,
Professor of Mathematics, United States Navy.

Hon. WILLIAM E. CHANDLER,
Chairman Board of Visitors, United States Naval Observatory.

UNITED STATES NAVAL OBSERVATORY,
Washington, D. C., September 27, 1899.

My DEAR SENATOR: At the July meeting of the board of visitors at the Observatory I submitted some ideas concerning the organization of the Observatory. In compliance with a suggestion of the chairman of the board, I respectfully offer a few comments on the present status of the Observatory, and the changes which I think are practicable. My opinions are based upon a service of twenty-seven years in the Navy, eleven as a line officer and sixteen as a professor of mathematics at the Observatory.

During that time the Observatory has been subjected to almost continuous criticism from the general body of astronomers outside of that institution; from my acquaintance with its history this has apparently been the general condition during its existence. Some of this criticism has undoubtedly been actuated by selfish motives; most of it, however, represents a dissatisfaction of astronomers outside of the Observatory with its failure apparently to reach the high standard of accuracy and the continuity of work which should be expected of a Government observatory with the generous support which it has received. The almost unanimous opinion seems to be that the cause of the failure of the Observatory to meet the expectations of the astronomical people of the country is due to a lack of competent, professional direction; and the idea is generally entertained that it will not be possible for it to reach the high standard justly expected of it except under the administration of an experienced astronomer.

Under the present conditions it seems to me that the attainment of this ideal organization is not practicable for reasons which it is not necessary, at the present time, to discuss; and I wish to make only such suggestions as seem to be practicable and within reach. A reference to my report on the European observatories and to the letter submitted to the conference committee will fill up any lack of definiteness in this respect.

I. I consider it of the first importance that a board of visitors should be established by law to visit annually the Observatory and to make an advisory report to the Secretary of the Navy upon its operations, and to make recommendations concerning the future transaction of such work and upon the financial expenditures of the Observatory.

Such a board is generally desired by the astronomers of the country, as well as by the officers of the Navy in general; and the enactment of legislation to make such a board a permanent feature of the Observatory administration would meet with no opposition.

This feature of Observatory organization is in my opinion the only one which can at the present time be attempted by legislative action with any assurance of success. All other desirable reforms can be more quickly and certainly reached through the authority possessed at the present time by the Secretary of the Navy.

II. The astronomical director, as at present, should be charged with the direction of and responsibility for the proper execution and publication of all astronomical work which is carried on at the Observatory.

He should have charge of all instruments and accessories used for such work, and in the proper distribution of the personnel.

In the execution of his duties he should consult at stated periods an astronomical board, to consist of all the professors on duty at the Observatory, to which should be referred all questions of scientific nature, and any extensive changes or repairs of instruments.

He should, so far as consistent with his responsibility, intrust the management of the various branches into which the astronomical work of his department may be divided to the persons placed in charge of such work.

He should thus find time to take part himself in the observations.

The director of the Nautical Almanac is now by law entirely independent in the management of that department of Observatory work, both as to finances and per-

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sonnel. It seems to me that the astronomical department should be placed, as nearly as practicable, upon the same footing, leaving to the Superintendent the immediate direction of the nautical department and the general government of the Observatory as the head of the institution.

As it seems probable that I may be successor to the astronomical director if the present form of administration is continued, I desire to submit for the consideration of the board an outline of the work which I should like to undertake and the methods by which it should be carried out.

III. The chief aim of the Observatory should be to make fundamental observations of the highest attainable accuracy which will advance the science of astronomy. This will best carry out the utilitarian aim of the Observatory to advance the art of navigation.

FUNDAMENTAL OBSERVATIONS.

IV. (1) The installation of the clock system of the Observatory should be radically changed—one or two clocks should be so mounted as to be kept practically at a constant pressure and temperature. From what I have seen in the European observatories I believe this is entirely and easily attainable.

(2) Determination of right ascension should be made with a meridian transit instrument.

(3) Declinations should be observed with a vertical circle.

(4) Observations of the planets and other miscellaneous objects, including general star catalogues, should be carried on with the 9-inch transit circle.

While the Observatory is not at present possessed of a suitable transit instrument, the cost of such an instrument is so small that it ought not to be considered an obstacle to the establishment of this important branch of the Observatory work upon a basis which may be reasonably expected to endure for many years without change.

The vertical circle, although of somewhat small optical dimensions, may prove to be sufficient for observations of declination.

(5) The 26-inch equatorial should have its time divided equally between micrometrical observations and spectrographic measurement of motion in the line of sight. The instrument is now provided with all the necessary accessories for this latter work, and observations are now in progress as a part of the routine work. The reduction, however, is badly hampered by the lack of a suitable micrometer microscope, which would cost about $200.

This latter branch of work, it seems to me, giving as it does measurements of high precision, is as much a part of the general plan of the Observatory as meridian observations.

(6) The 12-inch equatorial, under the general direction of the astronomical director, although needing considerable overhauling, should be used by computers not otherwise assigned to instruments in prosecuting the work suited to its capacity.

(7) The prime vertical transit should be devoted to the observation of a few bright stars for the study of variation of latitude and the constants of aberration and nutation.

To make such study a thorough one, the investigation of the variation of latitude should also be carried on with the vertical circle used as a zenith telescope, in accordance with the plans of the geodetic conference.

(8) In all the work to be carried on by the various instruments I should insist upon the principle of the highest attainable accuracy as the proper standard of our work rather than the number of observations.

To such end the investigation of the "instrumental constants" should be regularly carried on as a part of the routine work of the various instruments.

V. Another thing of the greatest importance is the prompt publication of results. I should endeavor to so restrict the observations, if necessary, that the annual results of the observations could be ready for publication within a period of a year.

I should like also to submit to the board a consideration of the question of the advisability of continuing the present plan of publishing all the observations in the annual volumes; whether it would not be better to defer the publication of such observations as would constitute a continuous series until the completion of such observations and publish them as a whole in the form of a memoir. Under the present system much of the time of the computers, as well as the professors, is taken up with unnecessary labor in the preparation of the annual publications, the results of which must to a considerable extent necessarily be entirely republished in a subsequent treatment of special subjects.

VI. It is highly important that the next two vacancies which will shortly occur in the corps of professors of mathematics should be filled with special reference to the needs of the Observatory. If the astrophysical work of the Observatory is to be carried on as suggested above, one of these vacancies should be filled with refer-

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ence to experience in that line of work. The other should be selected with special reference to his attainments and experience in the mathematical investigation of the higher problems of astronomy. The present board could hardly render more important service to the interests of the Observatory than by aiding in the securing of two professors for those vancancies with special reference to the future needs of the Observatory.

Very respectfully,

S. J. BROWN,
Professor, United States Navy.

Hon. WILLIAM E. CHANDLER,
Chairman Board of Visitors.

EXHIBIT L.

[Extract from Secretary Long's report for 1897 regarding professors of mathematics.]

PROFESSORS OF MATHEMATICS.

The Department recommends that the statute authorizing the appointment of professors of mathematics be so amended that, without disturbing those who now hold the office, which would be unjust to them, no further appointments shall be made. The reason for the creation of the office has passed away. These professors were, at first, teachers of midshipmen on board ship, and were thus exposed to the dangers of service in war and at sea. They were therefore properly pensioned by a place upon the retired list. To-day their name is largely a misnomer. Under the law, one is assignable to the teaching of ethics and English studies, one of Spanish, and one of drawing. In fact, only one teaches mathematics at the Naval Academy; several of them are on duty at the Naval Observatory; two are librarians; one is engaged in ordnance work, and another in the Bureau of Yards and Docks. They have no service at sea, and there is no more reason why hereafter the retired list should be open to a new appointee to the work now done by this corps than to any other employee in civil life.

If this recommendation is adopted by Congress, it will be necessary to provide for the appointment of astronomers at the Naval Observatory, to take the places as they shall become vacant of existing professors of mathematics who now serve in that capacity. There should be five astronomers, as at present, and the salary of those hereafter appointed should be sufficient to make up for the refusal to them of the privilege of retirement, and also to secure men of high scientific attainments, adequate to the demands of one of the most capable observatories of the world. As the above astronomical corps is now full, no appointment under the new statute proposed will be necessary till a vacancy occurs.

EXHIBIT M.[1]

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[1] This list, which makes no pretensions to completeness, contains the titles of various papers referred to in the historical sketch of the Observatory.

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APPENDIX.

EXHIBIT N.

REPORT OF PROF. S. J. BROWN, U. S. N., UPON THE ORGANIZATION AND METHODS OF WORK OF EUROPEAN OBSERVATORIES.

UNITED STATES NAVAL OBSERVATORY,
GEORGETOWN HEIGHTS,
Washington, D. C., February 19, 1896.

SIR: I have the honor to submit to the Department the appended report upon the Government observatories of England, France, and Germany, in accordance with the Department's orders of July 13, 1895, directing me to visit Greenwich, Paris, and Berlin, "for the purpose of observing and reporting upon the organization and methods of work of the national observatories in those cities."

In addition to the observatories specified in the orders, I append also brief reports upon the National Observatory of Holland, at Leyden, and the Imperial Observatory at Pulkowa, near St. Petersburg. These observatories had each a special interest on account of their instruments and work, and were visited at my own expense during times which could be thus utilized without interference with the duties assigned me by the Department.

It was my intention to prepare for publication a quite extensive description of the improvements in instruments and observatory methods since the date of Lieutenant Winterhalter's report to the Department in 1889, but as these matters are generally well known to astronomers, from the observatory publications and current astronomical literature, I have limited this report to the important features of the national observatories of Europe. Their organization and administration, and the work accomplished largely as the result of these, I have endeavored to briefly and clearly describe.

I should not feel that my duty had been carefully and honorably fulfilled should I fail to ask the attention of the Department to the contrast between the organization and methods of the principal European observatories and our own institution. The organizations of those observatories are essentially the same, and represent the experience of many years of successful astronomical work.

In all of them there is recognized the right of astronomers outside of the observatories to a definite interest in the work of the Government institutions, and the necessity of a strict legal control of the character and continuity of the observations and the instrumental equipment for their prosecution. There is no doubt that their successful work has been largely due to the recognition of these principles.

The careful study of these matters has led me to the conviction that the future success of our observatory will depend upon the recognition of the vital points which appear in the organization of the European observatories.

Very respectfully,

STIMSON J. BROWN,
Professor of Mathematics, United States Navy.

The SECRETARY OF THE NAVY,
Navy Department, Washington, D. C.

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THE ROYAL OBSERVATORY AT GREENWICH.

Founded in 1675, this observatory has always been under the office of the Admiralty, and is in this sense strictly a naval observatory. Beginning at a time when exact observation in astronomy was in its earliest infancy, its foundation was laid on a strictly utilitarian basis. Its object is precisely stated in the instruction contained in the warrant of each astronomer royal: "To apply himself with the most exact care and diligence to the rectifying the motions of the heavens and the places of the fixed stars, in order to find out the much-desired longitude at sea, for the perfecting the art of navigation."

The broad and sound organization which was adopted in its earliest days has survived to the present time, with only such modifications as its growth with the great advances of observational astronomy have rendered advisable. It is not too much to say that its influence has been greater than that of any other existing observatory. Its observations of the present time may be surpassed in accuracy by those of some other observatories possessing instruments of better design and following better methods in their use, but its persistent and long-continued series of observations of the sun, moon, and planets, and of the principal fixed stars have placed its work almost beyond comparison.

Its earlier star catalogues, commencing a century and a half ago, practically define the beginning of exact observational astronomy. Although it has often been left to outside sources to make the exact investigation of these catalogues by their comparison with others, necessary for the removal of the systematic errors to which all such work is liable, this does not diminish its credit for the persistent adherence to its policy which has distinguished its astronomical work from the beginning.

Its work in the field of terrestrial magnetism presents the same continuity of plan. Beginning with earliest attempts to study systematically the phenomena of terrestrial magnetism, continuous observations have been kept up to the present time. The establishment of this branch of observatory work was the result of the epoch-making researches of Gauss, Humboldt, and Weber, by whose efforts international cooperation was enlisted for the establishment of a chain of observatories at widely separated points of the earth. One of these temporary stations has been continued as a permanent magnetic establishment. On account of the interesting and intimate connection between the phenomena of terrestrial magnetism and the activity of the sun, as shown by the number and condition of sun spots, the surface of the sun has been daily observed, whenever possible, since the establishment of the magnetic observatory, and from the early days of astronomical photography daily photographs of the sun have been made. These, in connection with the photographs taken in India and Mauritius, make continuous record of the condition of the sun's surface for almost every day in the year.

In the development of the art of navigation its services have not been less conspicuous. Beginning with the long administration of Sir George C. Airy (1835–1881), it has carried on annual competitive tests of chronometers for the navy which have been an important factor in the development of this invaluable instrument of navigation.

Its work in the field of astronomy, magnetism, and astrophysics has not interfered with the labors of the rating, testing, and issue of chronometers of the navy. What this work means is easily seen by the fact that during the last observatory year 1,048 chronometers and comparing watches were received for testing and rating, 1,026 issued to vessels, and 449 sent for repairs. Of this number about two-thirds were ships' chronometers.[1]

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[1] The annual competitive test has now grown to quite formidable proportions, the numbers given in the report of Astronomer Royal to board of visitors for 1898 being—

Box chronometers	252
Pocket chronometers	32
Deck watches	88
Total	372

This does not include those tested for other uses than the naval; in this year six for the Indian government.

The testing extends over a period of several months, during which the instruments

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Formerly the observatory was also charged with the inspection of all the nautical instruments of the navy, sextants, spyglasses, and binoculars. But as these tests were quite simple, requiring only a comparatively low degree of accuracy, it was found that this could be more economically done at the place of issue.

The following is a brief statement of the present organization and methods of work of the Greenwich Observatory:

The organization consists of—

I. Board of visitors.

II. The observatory organization proper, consisting of (*a*) the astronomer royal; (*b*) astronomical assistants, 5 first class, 5 second class; (*c*) supernumerary computers, 24 in number; (*d*) mechanics and unskilled laborers, 9 in number.

BOARD OF VISITORS.

The members of the board of visitors are appointed by royal warrant, and under the orders of the council which originated the board its membership has a fixed constitution, as follows: Presidents and ex-presidents of the Royal Society; presidents and ex-presidents of the Royal Astronomical Society; five fellows of the Royal Society; five fellows of the Royal Astronomical Society; the professor of astronomy at Oxford; the professor of astronomy at Cambridge; the hydrographer of the navy.

This board of visitors, by orders of council, is authorized: First, to direct the astronomer royal to make such observations as the board thinks proper; second, to inspect the instruments of the observatory and report to the Lords of the Admiralty upon the arrangements for keeping them in order; third, to make to the Lords of the Admiralty suggestions concerning the efficiency of the observatory; fourth, to meet at the observatory annually.

The duties of this board have never been performed in a perfunctory manner, although its methods of control have been from time to time modified, with advancing facilities for astronomical observations and printing results of the same.

It is now the custom of the astronomer royal to attend, by invitation, a part of the annual session of the board, where his annual report to the board is read and discussed. This report gives the results of the year's work in detail and the needs of the observatory in the way of personnel and material.

The board does not now practically direct the astronomer royal to make observations, but its influence in the work of the observatory is just as vital. The observatory and its instruments are, however, carefully inspected, and the approval of the board is necessary for the action of the Admiralty in making radical changes in the instruments or buildings or in the plans of work.

OBSERVATORY ORGANIZATION.

The astronomer royal is appointed by royal warrant. He is absolutely responsible for the character of the observations, the accuracy of the computations, the selecting and rating of chronometers for the navy, and the expenditure of appropriations for the observatory.

The first assistant is appointed by the first Lord of the Admiralty and is selected with a view of succeeding the astronomer royal in case of a vacancy in that position. He performs the duties of the astronomer royal in the absence of the latter and exercises a general supervision of the work of the observatory and makes observations with the various instruments.

The astronomical assistants are appointed by the Admiralty, usually upon the recommendation of the astronomer royal. They are charged by the astronomer royal with the responsibility of definite lines of work.

METHODS OF WORK.

The administrative methods are very simple. The astronomer royal exercises all the control and supervision of the work required by a reasonable interpretation of his instruction.

With the growth of astronomy the observatory has extended its work into other departments of astronomical research—in astrophysics and terrestrial magnetism.

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are subjected to various temperatures in the "temperature ovens," and involves considerably more labor than the care and rating of chronometers on charge for rating and issue. Of this latter class at the time of the report referred to there were—

Average daily number being rated	463
Total received, chronometers and watches	1,202
Total issued, chronometers and watches	1,135
Total sent for repair, chronometers and watches	519

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It would be impossible, even were it not unnecessary, for one person to direct, in all their minutæ, these various branches of research. The responsibility for the various branches of the observatory work has been placed upon the assistant astronomers as follows: Magnetic observatory, with one second assistant and four computers; photographic mapping of the heavens, with four computers; solar photographs and spectroscopic work, with four computers; time and chronometer service; laboratory and longitude reductions; altitude and azimuth, and equatorial computations, eleven computers; transit reductions and determinations of time; meridian zenith reductions.

The eleven computers are distributed by the astronomer royal according to the needs of the various branches of work.

The astronomical observations with the various instruments are made by the first and second class assistants not otherwise assigned in accordance with the routine instructions issued by the astronomer royal. At the present time some of the older computers are assigned to the various instruments for observations. But this is owing to a temporary deficiency in the list of assistants, pending the formal adoption by the Admiralty of the reorganization of the corps. This plan, submitted by the astronomer royal to the board of visitors and by them recommended to the Admiralty, aims to make the position of the assistants more attractive by giving them increased responsibility for their respective departments of work, practically on the lines of the present organizations of the observatories of Paris and Pulkowa.[1]

The practical work of the observatory is at present divided as follows:

1. The transit circle; sun, moon, planets, and fixed stars.
2. Altitude and azimuth instrument; observations of the moon.
3. Zenith telescope; stars near the zenith.
4. Twenty-eight-inch equatorial; observations of miscellaneous objects and spectroscopic work.
5. Nine-inch photographic telescope; Dallmeyer photoheliograph; photographs of the sun.
6. Thirteen-inch photographic telescope; photographs of stars for the International Star Chart.
7. Magnetic and meteorological observations.
8. Chronometer testing and rating for the navy.
9. Time service.

NOTABLE ADDITIONS TO BUILDINGS AND INSTRUMENTS.

A new physical laboratory is now building and will be completed in the near future. It will contain a 26-inch photographic telescope, now nearly finished; the 24-inch Lassell reflector; the present 12¾-inch equatorial telescope, which will be used as a guiding telescope to the 26-inch photographic telescope.

The portion of this building which is now completed is designed and used as a physical laboratory, the measurement of the photographic plates for the star chart of the heavens, and office accommodations for the force, which has outgrown its present quarters. In the basement has been established a workshop, fitted out with a fine set of machine tools; a small 2-horsepower gas engine and dynamo for the electric lighting of the observing rooms and instruments of the observatory, and a chronometer testing room. The total cost of the building is limited to £3,200 ($16,000).

A new altazimuth instrument is also nearly completed, as well as the novel building in which it is to be mounted. This instrument will continue the important series of observations of the moon begun early in the administration of Sir George B. Airy.

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[1] Since the date of this report the reorganization of the observatory staff, which was then under consideration by the Admiralty Department, has been approved and adopted (1896) with the "view of strengthening the supervisory power and increasing the subordinate permanent staff."

The organization is now as follows: The astronomer royal, 2 chief assistants, 5 assistants, 8 established computers, and 23 temporary computers, the latter number varying with the needs of the observatory work.

At the date of the last report of the astronomer royal, May 11, 1898, six of the established computers had been appointed. The remaining two vacancies will not be filled until the positions now held by the remaining two second-class assistants shall have become vacant.

One of the chief assistants has general superintendence of all the work in the astronomical department, and one of the astrophysical work, including the magnetic observatory and meteorology.

Each of the assistants has direct charge of one of the departments into which the observatory is now divided, there being at the present time seven departments, although this number will eventually be reduced to five.

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All the principal instruments and observing rooms are now equipped with efficient and economical electric light installment. The current is furnished from storage batteries charged by the dynamo above described. Its economy can best be judged from the fact that the annual appropriation for gas and fuel is only £80, while the labor required for its attention is supplied by the assistant mechanician without much interference with his other duties.

The careful study of this institution leaves an indelible impression of the economy and efficiency of its organization. The annual reports of the director invariably show the reductions of the observations as far advanced as the nature of the work will admit, usually but a few months in arrears. At the date of the last report to the board of visitors, June 1, 1895, the manuscript copy of the volume for 1894 was in the printer's hands. These annual volumes, containing in detail all the observations which are of such a nature as to be currently published, have grown to enormous proportions, and take up a considerable part of the observatory force in the mechanical work of proof reading. Yet in addition to these annual volumes, since the middle of this century, the following valuable star catalogues have been published:

	Stars.
Twelve-year catalogue (1837–1846)	2,156
Six-year catalogue (1847–1853)	1,576
Seven-year catalogue (1854–1860)	2,022
New seven-year catalogue (1861–1867)	2,760
Nine-year catalogue (1868–1876)	2,263
Ten year catalogue (1877–1886)	4,059
Ten-year[1] catalogue (1887–1896).	

Appropriations, 1895–96, Greenwich Observatory.

No.	Title.	Salary.	Amount.	Remarks.
	Astronomer royal	£1,000	£1,000	
	Chief assistants	500–600	522	
4	First-class assistants	320–450	1,641	
4	Second-class assistants	200–300	970	
(11)	Supernumerary computers	.....	750	Number at discretion of astronomer royal.
	Magnetic superintendent	320–450	339	
	Assistant	200–300	200	
(5)	Supernumerary computers	.....	330	Do.
(4)	Computers	.....	250	Photographic star chart.
1	Second division clerk	.....	191	
1	Assistant paymaster	.....	150	
	Wages of watchman, gate porter, laborer, etc.	.....	244	
	Wages temporary laborers, workmen, etc	.....	655	
	Total	.....	7,242	

Total personnel	£7,242
Expense of board of visitors	70
Repairs to instruments, new instruments, etc	150
Photographic supplies	150
Magnetic observatory, supplies, etc	190
Contingencies	200
Fuel and gas	80
Electric light installation	100
Total	8,182

[1] Nearly completed (in 1898).

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THE NATIONAL OBSERVATORY OF FRANCE, PARIS.

The present organization of the Paris Observatory, under the minister of public instruction, representing the experience of more than two centuries of continuous existence of the observatory, amidst many changes of government, approaches in its final form closely to the ideal.

By its admirably constituted Observatory Council it secures the friendship and cooperation of the scientific men outside of its immediate personnel. By the legal organization of the Observatory Committee it secures the efficient and energetic prosecution of the scientific work of the observatory by giving the responsibility and credit of the work to the persons by whom it is actually performed. By the cooperation of the two it places the scope and character of the observations and the personal relations of the staff of the observatory to its director almost entirely beyond individual caprice. By the method of selecting and appointing the personnel of the observatory it secures the certainty of obtaining efficient scientific workers.

The scheme of the present administration originated in a law (Presidential decree) of the 13th of February, 1872, and was enlarged and perfected by a similar decree of February 21, 1878. Below is given a brief synopsis, embracing the essential points of the organization under this decree. On account of the thoroughness with which every branch of the organization is treated, a translation of this decree is given in the appendix following this report, so far as it affects the Paris Observatory.

The plan of administration comprises:

The observatory organization.

The observatory council.

THE OBSERVATORY ORGANIZATION.

The personnel of the observatory consists of the astronomical director and five astronomers (astronomes titulaires), constituting the observatory committee, the senior of the five astronomes titulaires being the vice-director of the observatory; ten adjunct astronomers and seven aid astronomers; a variable number of auxiliary computers and astronomical students; a financial secretary.

The observatory committee is composed of the director (ex officio president) and the senior astronomers, who are the chiefs of the departments in which the scientific work of the observatory is divided. The committee is required to meet monthly at a fixed date, but may be called into extra session by the director.

The observatory council consists of eleven members, appointed by the President of the Republic for the period of three years. Its membership is composed as follows:

(1) Six members appointed, two each by the ministers of war, navy, and of agriculture and commerce, respectively, from persons distinguished for their scientific work.

(2) Four members elected by the Academy of Sciences.

(3) The astronomical director of the observatory.

The council is required to meet three times a year at fixed dates, but may be called into extra session by the minister of public instruction.

The director is the executive head of the observatory, and is charged with the proper coordination and execution of the work of the several departments; with affairs originating in the observatory committee and observatory council; with the presentation to the minister of public instruction of the estimates for the observatory appropriations, and a detailed statement of expenses at the end of the fiscal year.

The heads of the departments are charged with the proper execution of the work of their respective departments, the assignment of work to the assistants and computers placed under them, and the proper care of the buildings, instruments, and material of which they have charge.

They are required to make to the director a monthly summary report of the progress of the work in their respective divisions; but scientific questions concerning the work are reported directly to the observatory committee. They are required also to submit to the director yearly a general report on the work of their departments during the foregoing year, the work which it is proposed to execute in the coming year, and the needs of their departments for its efficient execution. They also communicate to the director the condition of the reduction of their observations in time that they may be completed and published during the year following.

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The observatory council meets three times yearly, at fixed dates, and advises upon the plan of work to be done at the observatory, the distribution of the personnel and material among the observatory departments, the annual budget prepared by the director from the reports of the chief of departments, repairs and construction of buildings and instruments, nominations and promotions of subordinates, and disciplinary measures of the observatory. The recommendations of the council, with the approval of the minister, become a part of the regulations for the government of the observatory.

APPOINTMENT OF SCIENTIFIC PERSONNEL.

The astronomical director is appointed by the President of the Republic upon the nomination of the minister of public instruction, who selects from a double list of two candidates each, presented by the Academy of Sciences and the observatory council, respectively. A vacancy in the corps of astronomers is filled in the same way—from a double list presented by the observatory committee and the Academy of Sciences. In both cases, however, the minister can present directly to the President in addition a candidate distinguished for his scientific work. The adjunct astronomers and astronomical aids are appointed by the minister upon the recommendation of the director, approved by the council of the observatory.

Up to the present time, however, vacancies have always been filled by the selection of the first choice of the nominating committee. The present director of the observatory is the first to be chosen under the operation of the existing law. His high scientific attainments and reputation as the foremost astronomer of France augur well for the future of the observatory.

METHODS OF WORK.

The scientific work of the observatory is divided into the following departments:

1. The department of meridian observations.
2. The department of equatorial observations.
3. The department of the international photographic star chart.
4. The department of astrophysics, time service, and meteorology.
5. The bureau of computations.

Besides these there is organized an administrative bureau, under the charge of the financial secretary of the observatory.

The present work of the various observatory departments is carried on in accordance with the plans adopted soon after the reorganization of the observatory in 1873, with some notable and important additions, and some modifications which the progress of astronomy has rendered advantageous.

The instrumental equipment of the observatory is as follows: The great meridian circle; the Bischoffsheim meridian circle; the Gambey transit instrument; the Gambey mural circle; the great equatorial coudé; the small equatorial coudé; the west equatorial; the east equatorial; the 13-inch photographic telescope.

Besides these principal instruments, there is a numerous list of spectroscopes, measuring instruments, etc.

The work of the department of meridian observations constitutes the fundamental work of the observatory, and comprises meridian observations of the sun, moon, planets, and principal fixed stars upon the great meridian circle. The head of this department has made as his especial work for many years a careful study of the constants of this instrument, in which he has used a number of ingenious devices. The most valuable of these is an improved Mercury reflection apparatus, by which observations of the nadir and stars by reflection have been made not only possible, but easy and efficient, notwithstanding the situation of the observatory in the midst of a populous region of the city and the close proximity of the steam tram cars and an underground steam railway. The importance of this improvement may be realized when it is stated that the disturbance caused by this traffic at one time rendered all fundamental work impossible.

The other instrument is a device for obtaining measures of the important constant, the astronomical flexure of the telescope, independently of the use of the telescope itself.

In the field of differential observations all the four meridian instruments are engaged in observations for the completion of the great Paris Catalogue, which will contain 32,000 stars and for which more than 350,000 observations have already been made. The work remaining to be done is the filling in of gaps caused by omissions and observations of stars whose positions show discrepancies due to proper motion or errors of record, requiring in all about 15,000 observations. As this is about equal to the average annual work of this department, the publication is confidently promised by the year 1899.

The most important service of the Paris Observatory to the science of astronomy in recent times is the origination of the scheme for making a photographic chart of

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the whole heavens, by international cooperation. In the formation of the details of this enormous work and in the practical execution of the observations, its influence has been second to no other observatory. The successful experiments of the Henry Brothers, extending over many years while assistants at the observatory, had enabled them to construct a photographic telescope with which a short exposure would register on the sensitive photographic plate the images of the stars much fainter than had been possible to observe except with the largest telescopes. Their experiments led to the conclusion that by this means could be constructed a map of the heavens which would exceed in accuracy the old method of observations with the eye, and which, with much less labor, would contain all the faint stars in the heavens, as far as it might be desirable to register them.

The interest excited in the scientific circles of Paris by these successes led to the assembling at the Paris Observatory in 1887 of the International Astrographic Congress. This meeting resulted in the perfection of measures for the accomplishment of this grand project, forming a new era in astronomy of precision. As a final result of the labors of the Congress and its permanent committees, the work was divided into zones of nearly equal area, and each of these zones assigned to the various observatories volunteering to take part in the international project. The zone assigned to the Paris Observatory is prosecuted by the department of photographic astronomy, under the direction of M. Paul Henry, whose technical work, in conjunction with his brother Prosper, has played so important a part in the origination and perfection of the instruments necessary to carry out the plan. At the present time more than two-thirds of the photographs have been taken; and their measurements are made by an especial bureau organized in this department, under the charge of Miss Klumpke, an American, assisted by four other ladies. The special instruments employed for this purpose, two in number, seem to be models of accuracy and convenience.

The interest of the French Government in the prosecution of this zone work has been sufficient to lead it to undertake the photographing of three more zones in the observatories at Bordeaux, Toulouse, and Algiers (in Africa).

In the department of astrophysics, time service, and meteorology noteworthy investigations have been made, particularly by means of an instrument invented by M. Delandres for obtaining by spectroscopic device photographs of the details of the sun's surface. In the general work of the observatory, of the highest importance to its fundamental work is the phenomenal performance of the standard clock of the observatory. The clock is inclosed in a hermetically sealed case, in which the air is practically kept at a constant temperature, pressure, and humidity. It is located in a vault of the main building, where the variation of the temperature is very gradual and small, but where the air is always near the point of saturation. The clock is sealed in the case at the temperature and pressure which may exist at the time, and the humidity, by the introduction of a chemical substance, is reduced to a constant amount, about 50 per cent. It has been found by experience that this humidity gives the best results, for when the air is artificially dried to a condition of low humidity the oil dries up and the performance of the clock is rendered unreliable. Unfortunately, no details of these interesting and valuable experiments have been published, but a careful inspection of the rates for a number of years shows its performance to have been surpassed by none, not even the normal clocks of Pulkowa and Berlin.

The annual appropriation for the maintenance of the observatory is 240,000 francs ($46,320). Of this sum, 164,260 francs is for the pay of the scientific personnel, at the present time numbering 31 persons. The remainder ($15,619) is devoted to the care and maintenance of buildings, instruments and grounds, heating and lighting, and supplies of all kinds; and the pay of all persons not upon the scientific staff of the observatory.

[Translation.]

"DECREE CONCERNING THE OBSERVATORY SERVICE.

"The President of the Republic of France, * * * decrees:

"ARTICLE 1. The observatory service, under the minister of public instruction, comprises (titulary) astronomers, adjunct astronomers, and astronomical aids, * * *

"ART. 2. The personnel of the observatory of Paris comprises:

"1. An astronomical director.

"2. Six astronomers.

"3. Ten adjunct astronomers.

"4. Astronomical aids.

"Students may be received into the establishment for securing the future supply of astronomers.

"A financial secretary is attached to the establishment.

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"The director and secretary are lodged in the observatory.

"Astronomers, charged with special work at night, by the minister, shall be lodged in close proximity to the observatory buildings.

"ART. 3. The astronomers, heads of departments, shall meet monthly in committee, under the presidency of the director. This committee may be called into extra session by the director.

"ART. 4. There is instituted at the observatory of Paris a council, composed—

"1. Of two members, representing each the minister of war, the navy, of agriculture, and commerce, distinguished for their work.

"2. Of four members of the Academy of Sciences and of the Bureau of Longitudes.

"3. The astronomical director.

"The members of the council are appointed by decree, for three years, upon the nomination of the minister.

"ART. 5. The astronomical director is charged with the general administration of the establishment, the correspondence, business arising in the council and in the committee, with the presentation to the minister of the estimates of the annual budget, and with the detailed account of the expenses of the establishment.

"He is especially charged to secure the proper coordination and execution of the work requiring the cooperation of the different departments and to secure the regularity of the observatory publications.

"No orders can be given without his approval.

"ART. 6. The scientific work shall be divided into several departments (services), each under the direction of an astronomer.

"The subordinates placed under the orders of a head of department shall perform the duties which may be assigned to him.

"The material of each department is placed under the charge of the head of the department.

"Requests having for their object the use of an instrument, either within or outside of the observatory, are referred to the committee. They may be referred to the council, who transmits them to the minister with its recommendation.

"Each head of department is required to submit to the director a monthly summary of the progress of his work. He reports directly to the committee scientific questions arising in his work.

"All matters requiring a permanent or temporary expenditure are submitted to the committee through the director.

"The heads of departments shall communicate to the director the condition of the reduction of his work at such time that the observations of the current year may be prepared for publication within the year following. They will supervise the printing of the same.

"In the last fifteen days of January, or later, they shall submit to the director a general report of the work of their respective departments during the past year on the work proposed for the ensuing year and of the needs of their departments.

"ART. 7. These documents shall be communicated to the council with the personal report of the director; the latter report, with the approval of the minister, shall be printed and distributed.

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"The assignments of the head of Departments shall be made annually; they may be indefinitely renewed.

"ART. 8. The council of the Observatory of Paris is required to meet three times per year at fixed dates. It may be called in extra session by the minister.

"The president, vice-president, and secretary are appointed by the minister upon the nomination of the council.

"The council advises upon the annual assignments of the heads of departments the plan of work to be followed, and the distribution of the personnel and material among the departments, upon the estimated budget prepared by the director, from the report of the heads of departments, on the construction of buildings and instruments, on the nomination and promotion of subordinates, on disciplinary measures.

"The action of the council, upon approval of the minister, form a part of the regulations of the observatory.

"After the distribution of the annual reports mentioned in the preceding article the council inspects the observatory establishment, designating two of its number to assist in the inventory of the material. Copies of the inventory are to be furnished to the minister.

"ART. 9. The directors are appointed for five years by the President of the Republic, upon the nomination of the minister, from a double list of two candidates presented by the Academy of Sciences and the observatory council.

"The minister may, besides, propose directly to the President of the Republic a candidate distinguished for his scientific works.

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"ART. 10. In case of a vacancy in the position of astronomer (titulaire) the members of the observatory appointed by decree * * * shall present two candidates. The corresponding class of the Institute of France shall also present two. The minister may besides present directly to the President of the Republic a candidate distinguished for his work.

"ART. 11. The adjunct astronomers and astronomical aids are appointed by the minister, upon the nomination of the director, approved by the observatory council.

* * * * * * *

"Done at Paris the 21st of February, 1878.

(Signi) "M'l DE MCMAHAN,
"President of the Republic."

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BERLIN OBSERVATORY.

Although a state institution, the Berlin Observatory is strictly a university organization. Its director is the professor of astronomy in the University of Berlin. For this reason its organization and work has not the special interest which attaches to the Government observatories of England, France, and Russia and the Royal Observatory of Potsdam. Its present situation in the midst of a populous section of the city, in close proximity to a large iron manufactory, restricts its work to a limited field. Although its able astronomical corps and the possession of instruments suitable for the exacting requirements of fundamental observations fit it for such work, it has not, for the above reason, in recent years attempted work of this character.

Its personnel consists of the director and three astronomical observers, dwelling in Government quarters close to the observatory. They are all paid from the university funds.

The principal instruments consist of two meridian circles, a universal transit, and a 9-inch equatorial, by Frauenhofer. The principal meridian circle, by Pistor and Martins, is interesting from the fact that it is an almost exact duplicate of the one in use for years in the old Naval Observatory at Washington, and which has been recently subjected to radical alteration. The Berlin instrument, built in 1868, with no essential alterations or repairs, is still in excellent condition for work of the highest accuracy, in fact its original value is greatly increased by the continuous and careful investigation of its constants during the years in which it has been in use.

The universal transit is an instrument designed by Professor Foerster, the director of the observatory, for a wide variety of observations. It has brought considerable celebrity to the observatory, through the discovery in 1888 of the periodic variation of the latitude by Dr. Küstner as an accidental result from a careful series of observations to determine by a new method the constant of aberration. Since that time the director of the observatory has exercised much influence in the attempt to organize, by international cooperation, a series of observations at suitably situated points for the systematic study of this important phenomenon. At the late geodetic conference in Berlin (October, 1895) methods were completed to carry this project into execution. The instrument to be used was designed by Professor Foerster, and will record all the observations photographically, thus freeing them from danger of systematic personal errors.

The Royal Astrophysical Observatory at Potsdam was designated at first as a branch of this observatory, but the necessity of removing it far from the deleterious influence of a large city, and the radically different character of the investigations, led to their entire separation.

One of the most important works of this observatory is its thorough study and investigation of its normal clocks. A fine clock by Tiede has been for many years kept at a constant atmospheric pressure by inclosing it in an air-tight case in which the air has been previously dried and reduced to a pressure of about one-half the normal pressure of the atmosphere. The temperature of the basement has a very small daily variation, but the annual variation is considerable. The clock was removed in 1894 for cleaning and repairs after running continually for eight years with a rate of remarkable uniformity. The performance of this clock has for many years been the subject of frequent articles in the astronomical and scientific journals.

Another Tiede clock is provided with a barometric compensation, which largely frees the rate of the clock from the effect of variations in the atmospheric pressure.

During the long administration of its present director, beginning in 1863, the following important catalogues have been observed:

Catalogue of 521 Bradley stars (1881).
Catalogue of 622 right ascensions of the Berlin Jahrbuch stars.
Catalogue of 2,100 stars observed between 1893 and 1896 (in press).
Zone catalogue of 9,200 stars (zone 25° to 20°) (in press).
Zone catalogue of 9,789 stars (zone 20° to 15°) (in press).

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ROYAL ASTROPHYSICAL OBSERVATORY OF POTSDAM, GERMANY.

The first Government institution established solely for researches in the field of astrophysics, is a monument to the liberality of the German Government and to the thorough manner in which the organization and building of its technical institutions is conducted.

From the time of Kirchoff's brilliant discovery of the meaning of the dark lines in the solar spectrum, the importance of an observatory especially equipped for the study of the problems of solar physics was a subject of frequent discussion in the various scientific societies of Germany, but the realization of such an institution first became financially practicable with the foundation of the German Empire.

The first outlines of such an establishment, to form a branch of the Berlin Observatory, were presented in a memorial to the minister of public instruction by the director of the latter observatory.

This memorial was referred to the Royal Academy of Sciences of Berlin for its consideration and advisory action. This body emphasized the importance of the subject, and advised the founding of such an observatory equipped for astrophysical research in its widest extent. This favorable report was followed in the next year by the appointment of a special commission of eight members to formulate a precise plan for the buildings, instrumental equipment and organization of an astrophysical observatory of the highest rank. Among this commission are seen the distinguished names of Helmboltz, Kirchoff, Auwers, Foerster, and Siemens. The plans submitted by this commission were approved and the necessary funds secured at the winter session of the Landtag in 1873–74. The commission was continued in existence for the practical execution of the project, and the services of a distinguished architect assigned for the technical plans of the buildings and the supervision of their construction.

At this early stage three of the personnel of the new observatory were appointed, two of them, Professors Vogel and Sporer, were assigned the designing and ordering of the instruments, and the third to the supervision of the details of the observatory buildings. For a more complete utilization of the opportunity, Professor Vogel made a protracted visit to Great Britain for consultation with the astronomers and physicists concerning the instrumental outfit.

A permanent subcommittee was named for the consideration of important questions arising in the building, and for the further organization of the observatory upon its completion. With the enlargement of its scope the idea of the new observatory forming a branch of the Berlin Observatory was abandoned, and a favorable site chosen near the city of Potsdam. The site was located on a hill some 600 feet in height, in the midst of a wooded region, and within a convenient distance of the city. The frequent train service between the city and Berlin, a distance of 14 miles, removed any inconveniences arising from its situation entirely beyond the deleterious influence of a large city.

The first buildings erected were the dwelling houses for the observers and the engineers of the water plant. The observatory buildings were begun in the fall of 1877, and finally completed in 1879, although sufficiently advanced for beginning observations the year previous. The provisional administration of the permanent subcommittee continued, however, until 1882, when it was formally turned over to the director, Professor Vogel. In the meantime the personnel of the observatory had been selected, and its scientific activity fully begun.

The main building contains the office rooms of the scientific staff, four laboratories, and the library. The subbasement contains the dwelling rooms of the janitor, a thoroughly equipped workshop, and a 6-horsepower gas engine and dynamo for charging the storage battery used in lighting the observing rooms and instruments, and for electric currents for laboratory experiments.

The power house contains the machinery for pumping the water supply from a well 180 feet deep, and a complete Pintsch gas-generating plant. This plant also supplies the water and gas for the geodetic and meteorological institutes, which are located a short distance on either side of the observatory.

Since that time there has been added to the observatory dwelling houses for the director in 1883, for the fireman and gate porter in 1889, and a detached observatory for the 13-inch photographic telescope for the observation of a zone of the international photographic star chart.

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The present scientific personnel of the observatory consists of the director, three observers, three assistants, and a small number of auxiliary assistants and computers, at the discretion of the director. The labor force contains a machinist and fireman, a gardener, gate porter, janitor, and one laborer.

The annual cost of administration is as follows:

Salaries of permanent scientific personnel	$9,375
Supernumerary scientific personnel	2,050
Commutation for quarters for three, at $165	495
Maintenance of instruments, laboratory supplies, etc	1,500
Library	500
Care and maintenance of buildings, grounds, and roads	1,613
Heating building and dwellings	475
Coal for machinery, gas, and electric plant	875
Contingencies	355
Total	17,238

The instrumental outfit, from the nature of the work, naturally falls into two classes—astronomical telescopes and auxiliary apparatus for the study of the problems which constitute the aim of the observatory. The telescopes are: 12-inch equatorial, for spectroscopic work; 8-inch equatorial, for observations of sun; 5-inch equatorial, for photometric problems; 6-inch photographic, for photographing sun, and a 13-inch photographic equatorial.[1]

Of instruments for use in connection with these telescopes for physical observation there are all manner of spectroscopes, from the simplest form to the most complete and powerful. The auxiliary apparatus comprises measuring engines for the photographic map of the heavens, apparatus for enlarging photographs of star spectra, and a powerful laboratory spectrometer.

The past work of the observatory forms a large part of the history of the new science, and has contributed a number of important inventions and discoveries. Its principal work has naturally been in the application of the spectrum analysis to the study of the physical nature of the stars. The application of photography to the spectroscope, successfully inaugurated in this observatory, has resulted not only in greatly extending the power of the instruments, but in important investigations and discoveries, the most noted of which was the accurate determination, with great precision, of the motions of the stars in the line of sight,[2] measurements which had hitherto proven unattainable.

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[1] Since the date of this report, a 31-inch photographic refractor, with equally powerful spectroscopes and other accessories, has been added to the instruments of this observatory. This telescope, ranking among the most powerful in existence, will be devoted entirely to astrophysical research.

[2] The importance of this advance may be realized by the fact that at the present time nearly all the great telescopes of the world are spending large portions of their resources in this important field of astronomical work.

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THE IMPERIAL OBSERVATORY OF RUSSIA, AT PULKOWA (NEAR ST. PETERSBURG).

Popularly but little known, this observatory stands preeminent amongst astronomers for the extreme accuracy of its observations. The manner in which it came into existence; its instrumental equipment, of the best attainable design and workmanship; its organization and administration deserve careful study, as exemplifying the ideal method of treating such technical subjects.

The project of building near St. Petersburg an astronomical observatory "of the highest rank, conforming to the existing state of the science of astronomy and capable of advancing it," was formally recognized in 1833 by an imperial grant of the money to build and equip the observatory and the appointment of a scientific commission of five members to formulate and carry out the plans.

The commission adopted for its solution the following problems:

1. To determine precisely the character and aim of the observatory.
2. To formulate a general plan of observations to conform to this aim.
3. To formulate the plan of its organization and administration.
4. To plan the observatory buildings and dwellings for the astronomers.
5. To estimate the annual budget for its maintenance.

The general plans formulated by the commission were, in 1834, approved by the Emperor, and Wilhelm Struve, one of the commission, selected as the first director of the observatory.

Two distinguished architects, professors of the University of St. Petersburg, were directed to draw up independent plans of the new establishment, which were in all respects to conform to the final judgment of the commission. On account of the peculiar aim of the institution, all contracts were freed from the usual forms of carrying on Government works.

The director was ordered to make a scientific journey for the purpose of discussing the work and instruments of the new institution with the distinguished astronomers and artists of Europe, and to invite proposals for the furnishing of instruments "the most perfect which could be built."

The list of great astronomers whose opinions were consulted in the realization of the broad scheme adopted by the commission comprises the great names of astronomy of this century—Argeländer, Bessel, Encke, Olbers, Humboldt, Schumacher; and the instrument makers to whom was finally intrusted the task of making the instruments for the observatory are no less renowned—Steinheil, Mertz (successor to Frauenhofer), Ertel, and the Repsold Brothers.

The plans of the observatory and its instruments, drawn up with such thorough consideration of the object in view, were carried out with the same care and deliberation. Officially dedicated in 1838, its scientific activity began in 1839, but the provisional control of the commission charged with its construction was continued until 1840.

The buildings, with notable additions to meet the requirements of astronomical discovery and advancement, are to-day as perfectly suited for their purpose as any in existence.

The principal instruments for astronomical observations, of the highest attainable precision, with no essential alterations or repairs, after more than half a century of active use, have to-day no superiors and but very few equals.

The additions to its buildings and instruments, comprising a 30-inch telescope, fitted with spectroscopes and accessories of appropriate power; a 13-inch photographic telescope, and a physical laboratory, represent the same high degree of excellence.

ORGANIZATION.

The organization adopted by the commission was formally promulgated by imperial edict in 1839, and further extended and improved by a similar decree in 1862.

The precise purpose of the observatory and the character and scope of its observations are defined by the decree as follows:

(*a*) Continuous observations of the highest attainable precision for the promotion of astronomy as a science.

(*b*) The perfecting of practical astronomy in its applications to the problems of geography, geodesy, and navigation.

(*c*) The encouragement and support of astronomical work in the other Russian observatories.

(*d*) To furnish opportunity for the officers of the Government services to perfect themselves in the methods of practical astronomy applicable to their duties in geographical, geodetic, and nautical work.

The present administration of the observatory, in accordance with these decrees,

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is in its essential features the same as at Paris and Greenwich, consisting in the general control of the observatory committee and the direct control of the observatory administration by the executive head—the director.

The observatory committee consists of the president of the Imperial Academy of Sciences (ex officio presiding officer); the president of the Imperial Geographical Society; director of the military topographical survey; chief of the Nicolia Academy (military); president of the Marine Committee; director of hydrography; permanent secretary of the Imperial Academy of Sciences; four members of the Imperial Academy of Sciences (chosen by ballot officers of observatory staff not eligible).

The personnel of the observatory is at present as follows: The director; four senior astronomers (one to be vice-director); six adjunct astronomers; two computers; one instrument maker; one financial secretary; and one scientific secretary.

The committee is charged with the supervision of the scope and character of the observations and the consideration of questions especially affecting the attainment of the aims of the observatory.

It is required to meet annually at the observatory at a fixed date, when the director submits his annual report of the finances of the observatory, of the scientific work accomplished in the past and the plans for the ensuing year, together with the needs of the observatory for the prosecution of its work and the increase of its efficiency.

After consideration of the report, with the necessary verbal explanations of the director, and inspection of the buildings and instruments, the committee submits its recommendations to the minister of public instruction.

The director is chosen by the Imperial Academy of Science of St. Petersburg, according to the regulations defining the election of its own members.

He is required to devote his energies entirely to the duties of his office and to see that all the resources of the observatory are directed to the accomplishment of the declared aim of the observatory as defined by the statute.

As the executive head of the observatory he distributes the scientific work among the astronomers and is himself required to take a part in the same.

The senior astronomers must be chosen from persons distinguished for their work in astronomy. They are appointed by the minister of public instruction upon the recommendation of the director approved by the Imperial Academy of Sciences.

They are charged by the director with the responsibility of the proper execution of the work which constitutes the special aim of the observatory.

The adjunct astronomers and computers are appointed by the minister upon the recommendation of the director.

The director may further take into the observatory, for the higher study of astronomy, students who have finished certain prescribed work. The director may then pay them for such work in the observatory as he may assign them and permit them to carry on some special work under the direction of some member of the permanent scientific staff. They are paid from the scientific contingent fund, and may not exceed at any one time four in number.

The financial secretary ("ekonom") assists in the financial management of the observatory and is responsible to the director for the proper care of the buildings and grounds.

The director, or with his approval the astronomers, may from time to time visit other Russian and foreign observatories for the purpose of keeping advised upon the improvements in astronomical methods.

The principal instruments of the observatory, and assignment of astronomical staff: The Ertel meridian transit, two astromomers; the Ertel vertical circle, two astronomers; the Repsold prime vertical transit, one astromomer; the Repsold meridian circle, one astronomer; 30-inch equatorial (object glass by Clark, mounted by Repsold Brothers), one astronomer; 13-inch photographic telescope, one astronomer; 15-inch equatorial, one astronomer; 7½-inch heliometer, and 4-inch photometric equatorial (Frauenhofer), one astronomer.

The Ertel meridian transit and vertical circle are engaged exclusively on fundamental observations—the sun and a small list of the principal fixed stars. The transit instrument is provided with two collimators, a fine spirit level, a special telescopic collimator for studying the variation of the level at different zenith distances, and with two meridian marks for the control of its azimuth. These last two accessories deserve special mention on account of their importance, and the further fact that, although this has been generally conceded, it is only in recent times that they have been adopted in any other government observatory.

The Repsold prime vertical transit is not equalled by any other instrument of its class for perfect design and workmanship, and the satisfactory manner in which it has fulfilled all the requirements of extreme accuracy. The objects observed with this instrument are limited to a very few stars, for the investigation of the constants of aberration, nutation, and the variation of the latitude.

The Repsold meridian circle is engaged in the formation of star catalogues and

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other miscellaneous work, referring all observations to the fundamental positions derived from the observations of the three preceding instruments.

It is the work of these instruments which has given the Pulkowa Observatory a decided preeminence for the extreme accuracy of its observations. The right ascensions of its fundamental catalogues are practically free from systematic and periodic errors, a preeminence shared in a lesser degree by but one other, Argelander's catalogue of 1830.[1] While their absolute determinations of declination are not free from systematic error, they are not equaled in accuracy by those of any other observatory.

The thorough and scientific treatment of their astronomical clocks, especially in recent times, deserves special mention. Some twenty years ago the Tiede clock was placed in the basement of the observatory, where the annual variation of temperature was 4° to 5° C. To protect it against the variations of the pressure of the atmosphere it was inclosed in an air-tight metallic case in which the annual variation of pressure has been about 0.10 of an inch.

Another fine clock, by Kessel, was provided with a barometric compensation designed by Professor Krueger. This compensation proved of unexpected efficiency and "so exactly performed its function that in the course of several months not the slightest trace of variation in the rate of the clock due to barometric changes could be detected"

Both these clocks are at the present time in good condition and maintain the same uniformity of rate for which they have been distinguished in the past.

All the instruments are thoroughly equipped with electric lights, furnished by a storage battery of 30 cells. The dome of the 30-inch equatorial is turned by an electric motor, the current for which is supplied by a storage battery of 40 cells. The latter battery has been in use for ten years with no repairs, while the electric lighting plant has performed well for two years with no repairs. They are charged from once a week to once in two weeks, depending upon the weather.

The dynamos for charging the cells are run by a 25-horsepower engine, which, with the steam pumps for the water supply, is run by the same boiler. The whole plant is attended by one mechanic.

The observatory has in its present mechanician an assistant of great value in such an institution, having served in that capacity for fifteen years at the Imperial Magnetic Observatory, Pavlovsk, under the direction of Professor Wild, one of the most eminent investigators in the field of terrestrial magnetism. Provided with a thoroughly equipped machine shop, the mechanician is competent to keep in thorough order all the varied apparatus of the observatory.

The annual budget of the observatory is 70.000 rubles ($35,000), of which 37,000 rubles ($18,500) is for the permanent staff of the observatory. For the expenses of the temporary scientific staff, of special researches, and the increase of the instrumental equipment, a special contingent fund of 12,000 rubles ($6,000) is assigned. For the maintenance and repairs of buildings, grounds, and instruments, heating and lighting, pay of temporary and permanent laborers, 20,000 rubles ($10,000) is assigned. These items, with 1,000 rubles ($500) for the library, make up the expenses of the observatory. Unexpended money is carried to the future credit of the observatory as a fund for the purchase of new instruments and accessories.

When it is remembered that all the staff of the observatory, including watchmen and permanent laborers, are domiciled with their families in the buildings of the observatory, the economy of its administration is strikingly shown.

Besides observatory publications, sixteen large quarto volumes, many important investigations are contained in the memoirs of the Imperial Academy of Sciences, with which the observatory has always had the most friendly relations.

The important constants of aberration and precession used in the American and British almanacs are adopted from Struves's discussion, while Peter's value of the nutation is used. The constant of atmospheric refraction determined by Gylden is now generally used.

In the new field of astrophysical research the 13-inch photographic telescope and the 30-inch equatorial have contributed some valuable results, most of which are published in current scientific periodicals.

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[1] My experience since the date of this report has only deepened my conviction that the principles and methods adopted in this observatory sixty years ago for prosecuting their fundamental work are still far in advance of those existing even at the present day in any other government observatory:

First. By the determination of right ascensions and declinations with separate instruments, each of which, by its proper design, is best adapted to secure the highest precision.

Second. By the design and successful application of accessories for controlling or studying the azimuth and level of the transit instrument.

Third. By the installation of its normal clocks, so as to free them largely from the effects of atmospheric variations.

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THE ROYAL OBSERVATORY OF HOLLAND, AT LEYDEN.

The National Observatory of Holland stands in intimate connection with the University of Leyden, the professor of astronomy in the university being the director of the observatory.

The modern observatory dates from the year 1860, when the present buildings were completed and the principal instruments mounted, consisting of a 6-inch meridian circle and two equatorials, one of 7 inches aperture, by Mertz, and the other of 6 inches aperture, by Frauenhofer.

The meridian circle of 6 inches aperture and 8 feet focal length followed the well-known model of its makers, Pistor & Martins. In the beginning it was supplied with the two principal accessories necessary for properly undertaking fundamental work—a carefully mounted normal clock and two meridian marks, after the well-known design of those in use at the Pulkowa Observatory since 1840. The constants of the instrument have from the beginning been made a subject of continuous and thorough investigation, as well as the rate of the normal clock by Höwü, which has shown a rate of remarkable uniformity. The proper temperature to be used in computing the atmospheric refraction, a factor of great importance in determination of the absolute declinations of the stars, has also been an object of thorough and valuable research for a number of years. The thorough study of these essential factors in fundamental work has given the observations of this observatory a high reputation for their accuracy.

Some years ago the instrument was thoroughly overhauled by the Repsold Brothers, of Hamburg. Its pivots, worn by the constant use of the spirit level, were reground, and the illumination of the instrument altered in conformity with the well-known method of the Repsolds. The instrument is now in excellent condition, and is still engaged in the field of fundamental work.

The force of the observatory consists of the director and two assistants. The instrument maker is a fine mechanic, and not only keeps in repair the various instruments, but adds many new accessories.

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